POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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A NEW STACK FOR FISK

IN that rather ramshackle section of Chicago's near south side which once was the center of the lumber district stands a structure whose imposing steel stacks have been a conspicuous feature of the landscape for many years. This is the Fisk station of the Commonwealth Edison Co., a great station in its day and an important link in the evolution of power development. For this was the first all turbine station and it was here that the first really large turbine, a 5000-kw. unit, went into operation. ¶ Many changes have taken place in the power industry since that day in 1904 when this historic unit first turned over and today the entire output of that machine would just about satisfy the excitation requirements of a modern unit, but through all these years Fisk station has remained an important element in the electrical system of the Chicago metropolitan area. The 5000-kw. unit has long been removed to Schenectady, where it stands as a monument to the art in the yards of the General Electric works, but the stacks of Fisk have remained the symbol of power development in Chicago. ¶ And now a new stack has made its appearance among the old ones at Fisk—a taller but more slender one. From a distance this new stack is not unlike the older ones, but in point of construction it represents a great advance over the old. Built to serve the new 30,000-kw. superposed unit now being installed, it is the largest all-welded steel stack in existence. Although this stack is an essential part of the entire new boiler and turbine installation, which will be a feature in the October number of Power Plant Engineering, the details of its construction are sufficiently unique to warrant the separate article which we are pleased to present in this issue on p. 553.

WITH THE EDITORS

Fuel Changes Present Combustion Problems

COAL HAS been the predominating fuel in steam power plants for so many years that it is considered almost the universal source of heat and many traditions have been established about its use in boiler furnaces. In each plant where coal from the same mine or district has been used over a long period of time, rules-of-thumb or easily remembered mathematical formulas, which are in fact only approximations, have been used to guide the firemen. Such practice has been helpful in bringing the efficiency of boiler operation up to a fairly high standard, but when changes are made in the fuel used a different set of conditions is encountered necessitating alteration in firing instructions.

Combustion is a chemical change, the uniting of certain elements of the fuel with the oxygen of the air. Coal is an extremely irregular mixture of chemical elements and compounds some of which are combustible, some inert. The principal combustible elements are carbon, hydrogen and a small amount of sulphur; carbon exists in both the free and combined states, hydrogen combined either with oxygen as water or with carbon and sulphur most commonly combined with iron. The various forms of inert materials consist principally of earthy substances that form ash or clinker. Some inert gases, however, are released during combustion and these pass off as part of the flue gases.

Dealing with such a chemical hodge-podge, it is little wonder that the firemen in boiler plants have grown to assume that, since carbon is by far the most common combustible element in coal, they are burning only carbon, but this is quite far from the truth since hydrogen, particularly in the bituminous coals, is an extremely important combustible element.

To assume that a definite percentage of CO_2 in the flue gases is the ideal for coal, regardless of its character, is a decided mistake. Even the burning equipment, furnace and boiler design have modifying influences that affect the flue gas analyses. A change of coals invites a check up on combustion conditions, both mechanical and chemical.

When a change is made from coal to oil or gas as fuel, the same ratios of flue gas constituents as for coal do not maintain for complete and ideal combustion. The scientific and safe method of establishing the proper gas analysis for any installation is to secure the ultimate analysis of the fuel, calculate the results of perfect combustion without excess air then, through tests and a study of daily operating results, establish the most desirable gas analysis for that particular installation and fuel. Thus the fireman will be given a bogey to shoot at, but to aid him in reaching the desired goal, he should also have specific instructions on draft readings throughout the setting, furnace and flue gas temperature readings, steam flow-air flow ratios and color of stack gases.

Readers of Power Plant Engineering who have been following the discussions appearing during the past year are well aware that differences of opinion exist among even combustion engineers as to the most economical condition to maintain and the most desirable type of instruments to use as guides for the boiler attendant. In problems where such a diversity of opinions exists, there can be little hope of finding one general solution, each installation becomes an individual problem for solution by the man in charge of operation.

Reheat

FOR THE PAST FEW YEARS the reheat cycle appeared to be as dead as the Dodo but the 2500 lb., 940 deg. F. Twin Branch installation proves that the cycle was only hibernating and it is now extremely unlikely that the moderate pressure, high temperature cycle will ever supplant it where the ultimate heat economy is justified.

Whether the approximately 4 per cent thermal efficiency held by the reheat cycle over the high temperature straight through cycle justifies the expense and bother of reheat has been questioned in many quarters. It is significant, however, that the new extension is being built by a company with years of experience in reheat plant operation and sufficient operating data to back up its decision. Furthermore, the company is now building several different types of plants, which eliminates the possibility of undue favoritism for reheat, there can be no question but that they think that the additional expenditure is justified and reheat may look forward to a successful comeback and long and prosperous reign as the king of heat economy.

Mental Limitations

WE ARE LIKELY to feel that the progress of mechanical development depends wholly upon the physical properties of materials available for use. Apparently this is but half the story, however, for Boss Kittering, director of the Research Laboratories of General Motors Corp., one of the best known commercial research laboratories in the world, says that the designer is hampered not so much by physical limitations of the materials with which he must work as with mental limitations.

Of course the mental attitude or limitations of the designer is a factor for the working of the human mind is such that progress must be made step by step. The really important limitation, however, is the mental inertia of the general public which refuse to accept designs and progress of equipment with which it is unfamiliar.

Either consciously or unconsciously the designer will limit himself to materials he knows to be available but after a product or machine has been built or planned so as to best serve the intended purpose, the design must be worked over so that its appearance and operation have not departed too radically from equipment with which the public is already familiar. Next time something new is to be considered try to look beyond this mental barrier to progress.

The Chevrolet—Forge

New 625-lb., 725-deg. F. power plant acts as efficient top for old plant while the bleeder-condensing turbine gives flexibility. Two 170,000 lb. per hr. pulverized coal fired boilers and one 7500-kw. turbine are installed in Detroit plant

LOCATED north and east of the Grand Trunk Railroad, close to a junction with the Michigan Central so that rail facilities from both systems are available, the Chevrolet-Forge Gear and Axle Division of General Motors Corp. stretches from Euclid to Westminster Avenues in Detroit, covers 80 a. and employs about 13,000. On this property the Chevrolet Motor Co. produces all forgings for all Chevrolet cars (and for some Pontiac models), all Chevrolet chassis springs and bumpers and does the machining and assembly work of Chevrolet front and rear axle units.

Primarily to supply steam to drop forge hammers, the first boiler plant unit was built in 1919, and arrangements made to use exhaust from the hammers to heat the feedwater and the buildings. The initial section consisted of three 200-lb., 825-hp. boilers, two air compressors, (one 1150 and the other 1325 c.f.m. capacity), a 50 t. per hr. coal conveyor, necessary forced draft fans and boiler feed pumps together with a boiler feedwater treating plant capable of handling 30,000 gal. per hr.

As the demand for process steam increased more boilers were added, until in 1926 the plant consisted of six 825-hp. boilers. In 1928 it was again found necessary to increase the steam generating capacity of the plant, and a 1260-hp. boiler was added. By this time the steam demand was so great that the heating system could absorb only a small portion of the exhaust steam available and three 4375 kv.a., mixed pressure turbo-generators with jet condensers were installed to generate electric power primarily from the excess exhaust steam which would otherwise have been wasted. Circulating water for these jet condensers is furnished through salvage channels from process work and the heat is dissipated in a forced draft cooling tower 30 ft. wide, 180 ft. long and 30 ft. high with 24 motor driven fans.

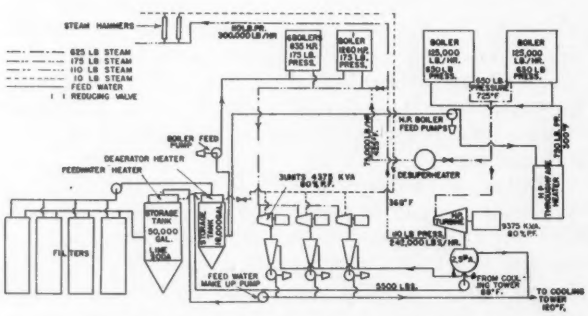

Fig. 1. Steam flow diagram showing how the new station ties in with the old. Normally the output of the old saturated steam boilers about matches the flow through the new reducing valve station but the new boilers can carry the entire load in emergencies

These boilers were operated at 175 lb. pressure and the process steam was reduced from this to 110 lb. pressure. This process load plus that of the power plant auxiliaries and high pressure steam requirements for the turbines, (due to unbalanced conditions between the electric load and the process steam load) finally reached a demand for 380,000 lb. per hr. During the depression and early recovery years the plant produced all of the steam requirements and about 40 per cent of the electrical power necessary for use in the manufacturing plant.

New High Pressure Plant

The late months of 1935 found the demand for steam so great that the spare boiler was put in use, leaving none available for cleaning or maintenance work, and, the purchased electric power demand had risen to 12,500 kw. It was obvious that a further power plant extension was necessary and exhaustive studies were made to find the most economical solution. These studies indicated that the installation of two high pressure pulverized fuel fired boilers and a condensing-bleeder type turbine would net the greatest return on the money invested. Steam conditions were set at 625 lb. ga. and 725 deg. F. at the throttle valve so that the bulk of the 300,000 lb. per hr. process steam could be bled from the turbine at 110 lb.

Actually a turbine with a bleeding capacity of 142,000 lb. per hr. was chosen, and the difference between this amount and that required by the process lines, or 58,000 lb. per hr., is supplied from the 175 lb. boiler system through the reducing stations in the old plant. The temperature of the bled steam is, by actual measurement, 386 deg. F., or, for 110 lb. ga., a superheat of approximately 42 deg. F. About 75,000 lb. per hr. of steam at 425 deg. F. is fed to the 175 lb. system

High Pressure Plant

By William J. Massey, Plant Engineer, and E. A. Sitter, Chief Engineer, Power Plant Chevrolet-Forge Div. of General Motors Corp., Detroit, Mich.

from a new high pressure desuperheating station. This mixes with an approximately equal quantity of 175 lb. saturated steam from the old boilers to give a final temperature of approximately 400 deg. F. in the 175 lb. system. The 58,000 lb. per hour of steam put into the process lines from the 175 lb. system closely matches the temperature of the bled steam.

To provide for flexibility of operation, a surface condenser was purchased so that the turbine could be operated under partial bleeding or straight condensing conditions, as the requirements might demand. Inasmuch as the turbine operates normally at maximum bleeding capacity with only about 5500 lb. of steam per hr. going to the condenser, a back pressure of 2.5 lb. absolute was selected.

To reduce the cost of pumping circulating water through the condenser under these load conditions it was decided to install two circulating pumps each large enough to handle sufficient cooling water to carry approximately 50 per cent of the load. Normally one circulating pump only is in use. For the same reason two hot well pumps were installed.

The generator is rated at 9375 kv-a. and arranged

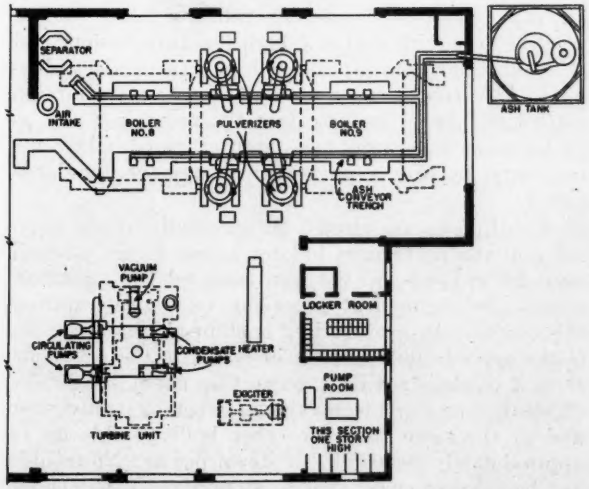

Fig. 2. Plan of the station. Equipment outlined solid is on the basement or ground floor, that shown dotted is on the operating floor

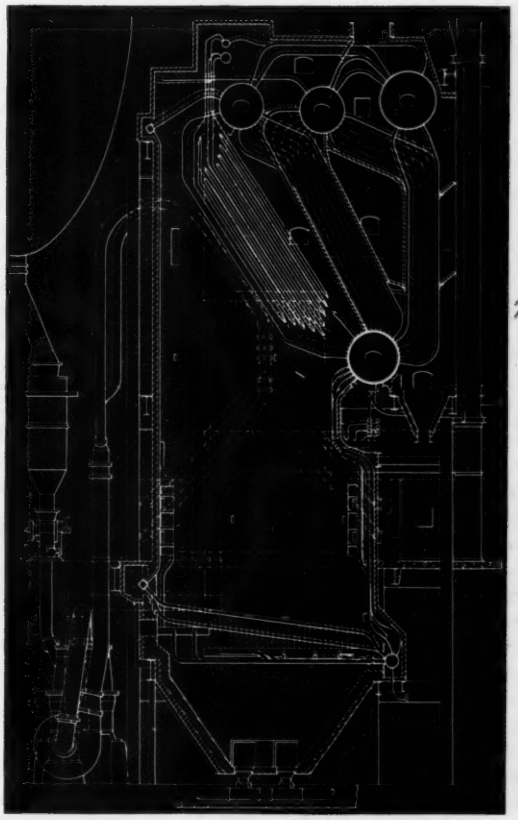

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Fig. 3. Cross section through one of the boilers. Forced and induced draft fans and air heaters are located above the boilers

for separate excitation from a dual driven exciter set on which the 90 to 135 v., 150-kw. direct current generator is driven normally by a 250-hp., 440 v. induction motor at 1180 r.p.m. A 250-hp. turbine operating at 165 lb. steam pressure and 8 lb. exhaust pressure acts as an auxiliary drive. This exciter set is sufficient to provide excitation for three 4375 and one 9375 kv.a. generators should they all be operated at the same time. The reliability of this dual set is checked daily during the light load period by opening the circuit to the motor, automatically transferring the load to the turbine.

High Pressure Boilers

Each of the two boilers selected has a normal steaming capacity of 125,000, with a 4 hr. guaranteed maximum of 170,000, lb. per hr. For short periods of time they have been operated at 200,000 lb. per hr. but usually carry about 150,000 lb. per hr. They are of the four drum bent tube type with the furnaces

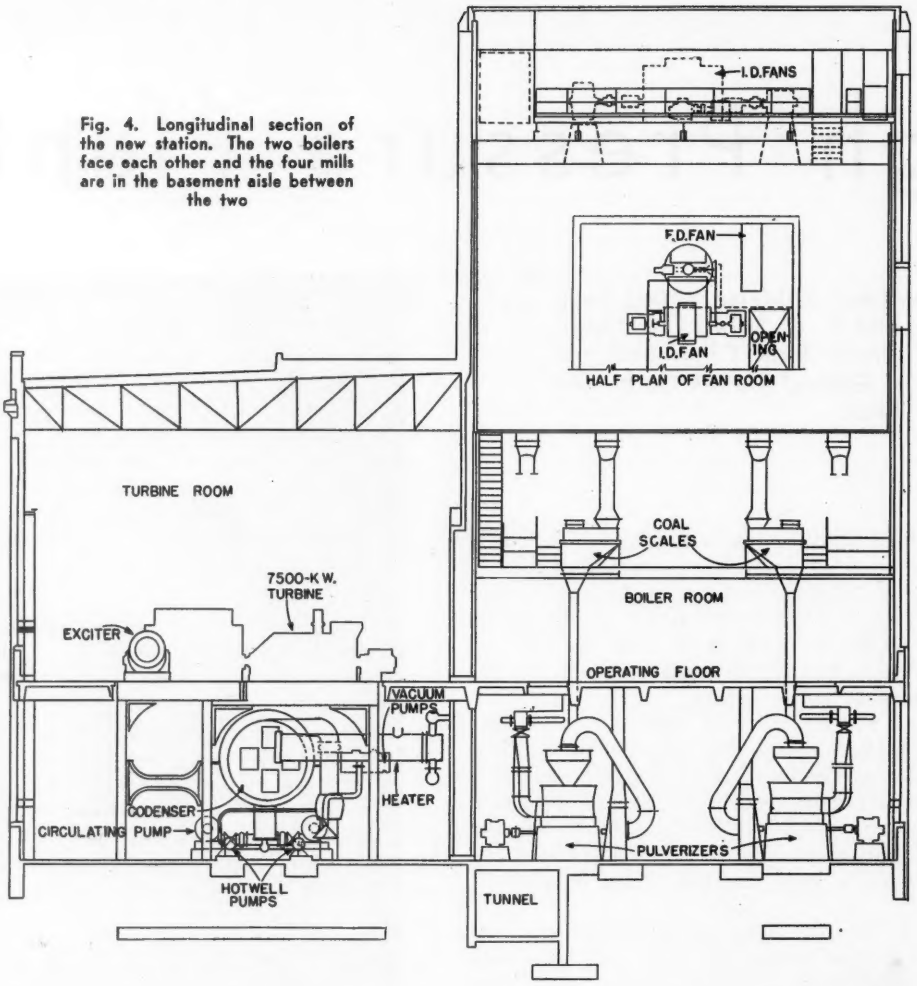


Fig. 4. Longitudinal section of the new station. The two boilers face each other and the four mills are in the basement aisle between the two

completely surrounded by water walls of bare and fin tubes and a water screen across the bottom. Ash from the hoppers is handled by a steam jet vacuum system into an outside bin located at the north end of the boiler room. Here it is inundated and loaded into gondola cars on the railroad siding adjacent to the bin. Steam used for ash conveying is washed before being exhausted to the atmosphere to prevent pollution of the air in the vicinity of the power plant. This same conveyor also handles all combustion chamber fly ash and soot and, if it is later deemed advisable, it can be extended so that the power plant can be vacuum cleaned.

Boilers are set face to face with the 700-t. coal bunker and firing aisle between them. The boiler control panels are located at the west end of this aisle while the east end opens directly into the turbine room. The usual building wall between the turbine and boiler rooms has been omitted for convenience and to reduce building costs. The accompanying drawings, Figs. 2, 3 and 4, show the location of the boilers and turbine together with their auxiliaries in the building which houses them.

Two pulverizers serve each boiler through eight tangential burners, four burners per pulverizer. Each pulverizer has a capacity of 8900 lb. of coal per hr. while pulverizing Pittsburgh No. 8 Seam coal with 10 per cent moisture and 12 per cent ash. Temperature of the primary air through the pulverizer is controlled by thermostats located in the top of the classifiers and is maintained at 175 deg. F. Secondary air leaving the air preheater is maintained at 540 deg. F. Preheated air is supplied to the feeder rolls to make feeding positive even with coal of a high moisture content and no trouble has been experienced with the feeders plugging. At various times a piece of steel or other foreign matter has found its way into the pulverizer and as no magnetic separators have been provided it becomes necessary to stop a pulverizer to remove the large pieces.

Small pieces are ejected automatically by the operation of the pulverizers but for larger pieces the mill must be stopped and the iron removed. The combustion-control equipment functions very nicely during this period. As a pulverizer is stopped, the coal feed to the opposite pulverizer is increased to the maximum so that the boiler will be generating about 105,000 lb. of steam per hr., the maximum from one pulverizer and at the same time the other boiler builds up to approximately 200,000 lb. of steam per hr. No trouble has been experienced due to stopping one pulverizer during working hours.

Coal is brought to the 700-t. bunker by an 18-in.

belt conveyor supplied by the unloader in the old plant. It is then carried by gravity through four steel ducts to the automatic weight scales, feeders, and finally to the mills.

Secondary air supplied to the burners is heated in rotary air heaters located with the forced and induced draft fans directly above their respective boilers. The forced draft fans are each capable of handling 51,000 c.f.m. at 100 deg. F. while the induced draft fans can each handle 102,000 c.f.m. at 410 deg. F. Both the forced and induced draft fans are motor driven by high and low speed motors and have supplementary damper control. The low speed motors will carry the boiler load up to 90,000 lb. of steam per hour.

Combustion control for these boilers is of the balanced draft type, operated from a master sender actuated by steam pressure in the header. Each boiler, with its own control panel and the master panel between them, can be operated either manually or automatically with the other, or one can be set on manual control at a fixed rating while the other is automatically controlled by the master panel. When both boilers are being controlled automatically from the master sender, steam header pressure is maintained to within 15 lb. of that desired.

Should the uptake draft be reduced to less than 0.2 in. of water while the boilers are in operation, automatic safety checks located in these uptakes immediately open to control, by means of mercoid switches, circuits to the mill and feeder motors, thus shutting off the supply of fuel to the burners and preventing undesirable positive pressures or possible explosions.

In addition to the necessary combustion control indicators and operating buttons, each boiler panel is equipped with ammeters for forced and induced draft fan motors and bowl mill motors, steam flow-air flow recorder and integrator, boiler steam pressure gage, a steam header pressure recorder on one and a steam header temperature recorder on the other, a CO_2 indicator-recorder, a feedwater flow indicator on one and a feedwater pressure indicator on the other. Each panel also has a six pen strip chart recorder showing: Fuel temperature to the burners; temperature of gas to preheater; temperature of gas from preheater; temperature of air from preheater; and a pen for recording the boiler water level in the top center drum. This water level is measured by a flowmeter mechanism, the high pressure side of which is connected to the steam space and the low pressure side to the water occupied space of the boiler drum. A loud bell alarm placed in the circuit rings for either high or low water levels. Up to the present time this alarm has sounded but once. This was due to high water caused by the oil circuit breaker on the 7500-kw. turbine tripping with the machine under full load.

Grilled openings are placed in the floor at both ends of the firing aisle through which the boiler operator can communicate with the bowl mill operator who also manually controls the boiler feed pumps. The operation of each of the four bowl mills can be observed through these openings.

Feedwater

Feedwater for these two boilers is made up from the following sources:—Condensate from the surface condenser; condensate from the heating system; and water from the forced draft cooling tower. Due to discharge from the jet condensers, water in the cooling tower is softer and more easily treated than Detroit City water. For average yearly operation the amount of city water which must be added to condensate and jet condenser discharge easily equals 85 per cent. This make up water is treated by a lime, soda ash, hot process softener, passed through filters and then discharged to a deaerating heater. The treating system has a capacity of 450,000 lb. per hr. and the water upon leaving the deaerator has the following analysis in p.p.m.: Phen. alkalinity, 21; total alkalinity, 46; chlorides, 13; hardness, 12; oxygen, 0.

Sodium sulphate is fed through the softening system to bring the sodium-carbonate ratio in the boiler to that recommended by the A.S.M.E. Colloidal iron is also added as the water leaves the deaerator to eliminate the last traces of oxygen and precipitate silica as calcium ferro silicate sludge in the boilers. Mono-sodium phosphate is fed direct to the boilers in sufficient quantities to eliminate hardness in the boiler water and to maintain an excess in phosphate of not greater than 35 p.p.m. as PO_4.

Boiler water analysis, in p.p.m., is as follows: Phen. alkalinity 480; total alkalinity, 520; chlorides, 150; hardness, 0; sodium sulphate, 1600; excess PO_4, 15 to 35; total dissolved solids, 2270.

After leaving the deaerating heater the feedwater flows by gravity to the intakes of the boiler feed pumps where it is discharged through a thoroughfare heater to the boiler. Feedwater leaving the thoroughfare heater is at 300 deg. F. temperature. The control of the amount of water fed to each boiler consists of the combined action on the main line admission valve by two thermostats, one actuated by the level of the water in the top center drum and the other by the amount of steam flowing from the boiler. Combined with, and in front of, this admission valve is a differential pressure spring operated valve which by its opening determines the quantity of water the admission valve can control. The amount of opening on this differential pressure valve is fixed by the difference between the feedwater pressure and the boiler pressure.

Two boiler feed pumps, one motor driven and one steam driven were installed, each with sufficient capacity to supply both boilers at maximum ratings. The motor driven pump is normally in operation with the steam pump for stand-by service. Should the motor driven pump fail the steam driven pump is automatically cut into service by a differential pressure operated throttle valve. By the same token, should the electrical pump be started while the steam pump is in service this action would automatically shut down the steam driven pump. When the steam pump is in service, pressure to the feed lines is controlled by an automatic constant excess pressure governor. The motor driven pump is controlled manually by varying the speed of a slip ring motor from 1770 to 1425 r.p.m. through 21 point rheostat. With this accurate speed control in addition to the operation of the differential valve in the feedwater regulator, it was thought advisable to eliminate any automatic feature on the motor driven pump. These pumps both have cast steel casings, bronze impellers and stainless steel trim throughout.

The thoroughfare heater which is under 780 lb.

water pressure on one side and 110 lb. steam pressure on the other, is protected against accident, caused either by failure of the condensate drain or ruptured tubes, by a high level mercoid float switch operating two motor driven valves in the feed lines. Operation of these valves cuts the heater out of service and by-passes the water around it. This feature automatically guards against the possibility of pumping 780 lb. pressure water to the steam side of the heater should one or more tubes fail in operation.

Steam generated in the water wall and boiler tubes is carried by the boiler circulation to the rear top drum where it is passed through a scrubber. In this scrubber the steam, which has a large quantity of solid material in it from the highly concentrated boiler water, is forced through a curtain of feedwater containing a small amount of solids and is washed free of undesirable material before going to the superheater. During six months of operation, three inspections have been made of main lines, valves, and the 7500-kw. turbine blading. These inspections disclosed the fact that steam leaving the boilers is in a remarkably clean condition there being no evidence of dirt or deposits on pipes, valves or turbine blading.

Boiler steam headers, together with the common main, are entirely of the arc welded type. All main steam valves with the exception of the desuperheating station reducing valves were welded integrally with the lines and the welds stress relieved by the electrical induction coil method. On the boiler feedwater lines flanged valves were selected but at all other joints the arc welding process described above was followed. All steam and feedwater piping has spring mounted hanger supports and is well braced to prevent vibration. Wherever possible expansion joints have been omitted and loops or bends used in place of them.

Reducing and Desuperheating Station

The reducing and desuperheating station was primarily installed as a by-pass around the 7500-kw. turbine. In the event of failure of this machine, the entire boiler output can be fed through the desuperheaters into the 175 lb. boiler main and through to the process lines as was originally done in the old plant. Failure of the high pressure turbine means an increase of purchased power by 400 kw. because only one of the 4375 kv.a. turbo-generators is available for standby work.

This station is made up of two reducing valves, with one desuperheater of the cartridge type. Under normal operating conditions approximately 75,000 lb. per hr. or high pressure steam is fed through the station into the 175 lb. main at 425 deg. F., this arrangement making it possible to shut down two old boilers and thereby increase the steam generating plant efficiency. It was deemed inadvisable to use one reducing valve to handle a range of loads from 75,000 to 315,000 lb. per hr., therefore a 4 and 6-in. valve were installed, but under normal operation only the 4-in. valve is in use. The 6-in. valve is preceded by a motor operated gate valve remote controlled from the desuperheater panel. In the event of the loss of the 7500-kw. machine the turbine operator can quickly and easily cut in the 6-in. reducing valve to make the full output of the two new boilers available to the 175 and 110 lb. systems.

Forced Draft Cooling Tower

In order to take care of cooling the additional water used by the surface condenser of the 7500-kw. turbine, an extension was necessary to the existing cooling tower. When this was being planned it was deemed advisable to install a spray eliminator system as, in the past, steam rising from the old tower and condensing in winter weather made bad ice conditions in the vicinity of the plant. All old forced draft fans were of the two blade aeroplane type. They revolved at 685 r.p.m., and considerable vibration was noticeable both in the tower and in the surrounding area. These were replaced by three bladed fans of the venturi type, operating at 357 r.p.m. These, together with the spray eliminators, have shown a greatly improved performance in water cooling as well as the practical elimination of ice, moisture and noise in the surrounding area. The tower was lengthened from 180 to 210 ft. and now has a total of 28 venturi type motor operated forced draft fans. For average weather conditions it will cool 21,000 gal. of water per minute from 120 to 88 deg. F.

Operating Data

During the 6 mo. period that this equipment has been in use very satisfactory results were obtained and the operating experience has been most interesting. Little test work has been carried on to date, but this will follow in the near future as time permits. The following is a summary of the more unusual operating experiences:

Air heaters were installed with two soot blower elements each, one below the plates and the other above them. These elements using superheated steam were both operated for a period of about 4 mo. when, by experiment and inspection, it became evident that the use of the lower element only was required to keep the plates in a clean condition. For a period of 2 mo. the boilers have been operated at high ratings with only the lower preheater soot blower in use. Late inspections and observations show no slagging, fly ash collection or increase of temperatures in the uptakes. The soot blowers are so arranged that soot may be blown in the direction of the flow of gases as well as against it. It was found that when blowing against the direction of the flow of gases, the combustion control system behaved badly. Inasmuch as superheated steam is used to blow soot it was decided to try blowing in the direction of the flow only for a period of one week. This was done and no increase in temperature of stack gases was noted, so the use of the opposite blower has been permanently discontinued and the combustion control system functions very well during the soot blowing period.

Rotating preheater elements and the induced-draft fans are inspected periodically for wear. To date no noticeable wear has taken place in the preheater element. The fan blades, which are made from three-sixteenths-inch stock, have worn away 0.012 in. at their mid-length only, but there is no wear at the ends nor on other parts of the fan. The fan-housing liners show a bright polish surface, but no wearing of the plates has taken place. No doubt the small amount of wear

of these fans is due to the low speed at which they operate, the maximum being 720 r.p.m.

Induced draft fan dampers are made up of four louver sections which gives fine control. The trailing tips of the outer sections originally faced toward the sides of the breeching with the result that the gases throttled by these sections were directed against the breeching side walls. Recently, it was found that the 3/16 in. breeching plates at this point were worn completely through.

After repairs were made by welding in new plates, the louver sections were reversed so that the gases are now directed away from the breeching side walls. No further trouble is anticipated from this source. By way of explanation, the breeching takes a 90 deg. turn at this point which further aggravates impingement of the gases. The damper sections do not show any appreciable amount of wear.

After the boilers were in operation a few days it was found that the various furnace draft gages and regulator connections, where they entered the setting, would fill with ash and produce false readings or sluggish operation of the control system. This happened frequently and was corrected by drilling a ⅛ in. hole through the clean-out plug so that the small volume of air, entering the furnace through these openings, cre-

Principal Equipment Installed in the New Chevrolet-Forge Power Plant, Detroit, Mich.

BOILER ROOM

BOILERS: Combustion Engineering Co. 2—1662 hp. four drum bent tube type VB with 3800 sq. ft. of Elesco superheaters. Water wall surface 720 sq. ft.; boiler heating surface gas touched and water covered 12,900 sq. ft.; furnace volume 8600 cu. ft. Operating pressure 650 lb. per sq. in., 750 deg. F. total temperature.

PULVERIZERS: Combustion Eng. Co. 4—Raymond bowl mills driven by 125 hp., 1165 r.p.m. Allis Chalmers motors; capacity 8600 lb. per hr.

COAL FEEDERS: Combustion Eng. Co. 4, each driven by 1½ hp. motors at 1200 r.p.m. and equipped with reducers which have a range of from 11 r.p.m. to 40 r.p.m. through Stirling Variable Speed Controls.

BURNERS: Combustion Eng. Co. 8, Lopulco, type T, forced draft, size 8 in.

AIR HEATERS: The Superheater Co. 2, Ljungstrom type CG2X-16 each with 11,700 sq. ft. of heating surface. Driven by 3 hp. Allis Chalmers motors through W. A. Jones 200 to 1 reducers.

INDUCED DRAFT FANS: American Blower Corp. 2, Sirroco, each with a capacity of 102,500 c.f.m. at 7.5 in. W.G. and 410 deg. F. Dual driven by Allis Chalmers motors (1—200 hp. at 700 r.p.m. and 1—50 hp. at 430 r.p.m.) through flexible type Rawson couplings.

FORCED DRAFT FANS: American Blower Corp. 2, Sirroco, each with a capacity of 51,000 c.f.m. at 8.9 in. W.G. and 100 deg. F. Dual driven by 2 Allis Chalmers motors (1—125 hp. at 1770 r.p.m. and 1—40 hp. at 1160 r.p.m.) through flexible type Rawson couplings.

COMBUSTION CONTROL: Hagan Corp. 2 boiler control panels and one master panel with necessary sending and receiving regulators.

BOILER FEED PUMPS: De Laval Steam Turbine Co. 2 centrifugals rated 800 g.p.m. each at 2060 ft. head. One driven by a 600 hp. Allis Chalmers motor and the other by a 550 hp., 2900 r.p.m. De Laval steam turbine, 160 lb. steam pressure and 10 lb. exhaust pressure. The steam pump is controlled by overspeed and constant excess pressure governors.

CONTINUOUS BLOW OFF: Cochrane Corp. Composed of valves, flash tanks and a heat exchanger.

DEAERATING HEATER: Cochrane Corp. 1, capable of handling 400,000 lb. per hr.; water heated by 5 lb. pressure exhaust steam.

HIGH PRESSURE HEATER: Griscom-Russell Co. One, 4 pass, maximum steam pressure 450 lb. per sq. in. maximum water pressure 1000 lb. per sq. in.

FEEDWATER REGULATORS: Northern Equipment Co. 2 Copes, double control from water level and steam flow thermostats.

DIFFERENTIAL PRESSURE CONTROLS: Northern Equipment Co. 2 Copes.

MOTOR OPERATED FEEDWATER VALVES: Crane Co. 2, Type S & O 34,775 and SX 74 on bypass around high pressure heater.

MANUAL FEEDWATER VALVES: Crane Co. 8, 4 in., 76X; 4 for each boiler.

WATER COLUMNS: Reliance Gauge Column Co. 2 for each boiler with magnasite windows and reflecting mirrors.

NON RETURN VALVES: Edward Valve & Mfg. Co. 2, with special feature for opening and closing.

BOILER BLOWOFF VALVES: Yarnall-Waring Co. 4, Yarway tandem, Nos. 3918 and 3920, 2½ in.

WATER WALL BLOWOFF VALVES: Yarnall-Waring Co. 4, Yarway tandem, Nos. 3918 and 3920, 1½ in.

BOILER DRUM SAFETY VALVES: Ashton Valve Co. 4, Type 80,114, size 4 in. Discharge 67,500 lb. Two on rear drum of each boiler.

SUPERHEATER SAFETY VALVES: Ashton Valve Co. 2, Type 6—DI2 size 3 in. Discharge 36,000 lb. One each boiler.

STEAM TRAPS: Armstrong Machine Wks.

BOILER FEED STOP AND CHECK VALVES: Edward Valve & Mfg. Co.

PIPING: Lorne Plumbing Co. Arc. welded and stress relieved.

WELDING FITTINGS: Crane Co.

FORGED STEEL VALVES, miscellaneous small: Edward Valve & Mfg. Co.

PIPE COVERING: Johns-Manville Co.

BOILER ROOM ELEVATOR: Otis Elevator Co. 1000 lb. capacity; automatically driven by 4½ hp. Otis motor.

COAL SCALES: Richardson Scale Co. 4, 200 lb. size equipped with 1775 r.p.m. ½ hp. Westinghouse motors.

COAL HANDLING EQUIPMENT: Robins Conveying Belt Co. 50 t. per hr. capacity. Driven by a 5 hp. Westinghouse motor through a Falk Corp. 41.9 to 1 speed reducer. This conveyor system is an extension to the old equipment.

ASH HANDING EQUIPMENT: United Conveyor Corp. Automatic steam vacuum system with outside storage bin, unloader and exhaust steam cleaning tank.

DESUPERHEATING & REDUCING STATION: Swartwout Co. One cartridge type desuperheater with a 4 and 6 in. reducing valve; remote controlled from a master panel.

TURBINE ROOM

TURBINE: Westinghouse Elec. & Mfg. Co. 19 stage full condensing and 8 stage bleeding, 7500 kw., 3600 r.p.m.; for 625 lb. steam pressure at 725 deg. F. temperature. Generator rated at 9375 kv-a., 4800 v., 3 phase, 60 cycle.

EXCITER: Westinghouse Elec. & Mfg. Co. 150 kw. at 125 v. generator dual driven by a 250 hp. Westinghouse motor and a Westinghouse steam turbine at 160 lb. steam pressure 10 lb. exhaust pressure.

CONDENSER: Westinghouse Elec. & Mfg. Co. One 3 pass with 7750 sq. ft. of cooling surface made up of 3588 tubes, ¾ in. O.D., 11 ft. long.

CONDENSATE PUMPS: Westinghouse Elec. & Mfg. Co. Two 205 g.p.m. at 85 ft. head. Size 252 EA driven by 10 hp. Westinghouse motors.

CIRCULATING WATER PUMPS: Westinghouse Elec. & Mfg. Co. Two 12 in. centrifugal; 3800 g.p.m. at 85 ft. head. Driven by Westinghouse 125 hp. motors.

VACUUM PUMP: Westinghouse Elec. & Mfg. Co. Six C32 stage, operating steam pressure 125 lb. per sq. in.

BLEEDER NON RETURN VALVE: Atwood & Morrill Co.

ATMOSPHERIC RELIEF VALVES: Edward Valve & Mfg. Co.

RUBBER EXPANSION JOINTS: U. S. Rubber Co.

GENERATOR AIR COOLER: Westinghouse Elec. & Mfg. Co.

OIL FILTER & PUMP: William W. Nugent & Co., size 5-S with Viking pump.

INSTRUMENTS

BOILER WATER LEVEL RECORDERS (2): CO_2 RECORDERS (2): FEEDWATER FLOW INDICATOR (1): STEAM HEADER PRESSURE RECORDER (1): FEEDWATER PRESSURE INDICATOR (1): STEAM HEADER TEMPERATURE RECORDER (1): MILL TEMPERATURE RECORDERS (4): FLUE GAS TEMPERATURE RECORDERS (2): PRE-HEATER AIR TEMPERATURE RECORDERS (2): FEEDWATER FLOWMETER AND TEMPERATURE RECORDER (1): BLED STEAM FLOWMETER (PROCESS) (1): BLED STEAM FLOWMETER (H.P. HEATER) (1): DESUPERHEATED STEAM FLOWMETER (1): DESUPERHEATED STEAM TEMPERATURE & PRESSURE RECERDER (1): MULTIPOINT DRAFT GAGES (2): Republic Flow Meters Co.

AIR FLOW-STEAM FLOW METERS: Bailey Meter Co. 2.

BOILER STEAM PRESSURE GAGES: Ashton Valve Co. 2.

TURBINE STEAM PRESSURE GAGES: Ashton Valve Co. 4.

ELECTRICAL SYSTEM

TURBINE O.C.B. SWITCH: Westinghouse Elec. & Mfg. Co. 2000 amp., type B-28-BS. Metal Clad, lift type unit with potential transformers, differential relays and ground detector.

BOILER AUXILIARY PANELS: General Elec. Co. 5, 3 phase, 3 wire, 60 cycles, 440 v.

POWER TRANSFORMERS: Allis Chalmers Mfg. Co. 2, 400 kv-a., single phase, 4800/440 v.

TURBINE SWITCH BOARD: Westinghouse Elec. & Mfg. Co. panels with generator temperature indicator, kw-hr. meter, kw. recorder and indicator, d.c. ammeter and power factor recorder.

LIGHTING TRANSFORMER: Allis Chalmers Mfg. Co. One 100 kv-a., single phase, 4800/110/220 v. with automatic throwover feature to insure continuous lighting during load switching.

ELECTRICAL WIRING: Livingstone Electric Co.

MISCELLANEOUS

LOW LIFT PUMPS: Pennsylvania Pump & Comp. Co. Two, 4 in., 800 g.p.m., 60 ft. head driven by 2, 15 hp., 1750 r.p.m. Allis Chalmers motors. Used for pumping feedwater from filter tanks to deaerating heater.

LOW LIFT PUMP: American-Marsh Pumps, Inc. One, 75 g.p.m., 100 ft. head driven by 5 hp. 1740 r.p.m. Howell motor. Used for washing boilers.

LOW LIFT PUMP: American Marsh Pumps Inc. One 50 g.p.m., 50 ft. head driven by Howell 1½ hp. motor at 1730 r.p.m. Used for supplying cooling water to I.D. fan bearings.

COOLING TOWER EXTENSION: Lilie-Hoffmann Cooling Towers, Inc. Section 30 ft. long by 30 ft. wide by 65 ft. high, with four American Blower Corp. 9 ft. diameter, venturi type fans driven by Allis Chalmers motors and V-belt drives. Tower has spray eliminators and water diffusion fillers. The same company installed spray eliminators and water diffusion fillers on the old section and replaced 24 fans with American Blower Co. 9 ft. Venturi type with V belt drives.

ated sufficient draft to carry the finely divided ash with it. These openings haven't been cleaned since and no further difficulty has been experienced. The small amount of air entering the setting through the holes has no effect on the operation of the boiler.

Each mill has pulverized about 12,000 t. of coal to date. Some of this fuel was very abrasive in texture and while it was burned there was a marked increase in exhauster fan blade wear. In spite of this fact maintenance has not been excessive. The parts renewed to date consist of two sets of exhauster fan blades and one-third of the cast-iron liners in each of two exhauster fans. This does not mean that no wear is taking place in the mills for the bull rings in the revolving bowls are about half worn out, while the tires on the rolls still retain two-thirds of their useful life. It appears as though the tires will wear much longer than the bull rings, but a newly designed bull ring has recently been manufactured which, it is expected, will increase the life to match that of the tire.

While it is too early to obtain accurate maintenance costs, it appears as though the cost of renewal parts will be well below two cents per ton of coal pulverized. A recent test showed 82 per cent passing through a 200-mesh sieve and, as no sparklers are visible in the furnace, it appears feasible to reduce the fineness of the pulverized fuel. This will reduce the power consumption. At 150,000 lb. steaming rate the mills now consume 16.1 kw-hr. per ton of coal, and the power consumed is almost directly proportional to the rate at which coal is pulverized.

On several occasions during the first 3 mo. the automatic coal scales were in use, trouble was experienced due to failure of the scale hopper gate to close after the scale had discharged its load. Had there not been a 10 min. storage of coal between the scale and the mill, serious difficulty in maintaining the steam demand might have arisen. The trouble was caused by the coal scale hopper gate closing before the coal level in the feeder hopper below it had fallen far enough to clear the lip of the scale hopper gate.

Small lumps of coal caught by the lip of the gate and carried by it up to the scale hopper bottom prevented its full closure, thus stopping the automatic cut-in of the belt supplying the weight hopper and coal fed by this scale was then completely shut off. After considerable study of the situation, it was decided to weld a projecting plow shaped piece of steel at the center of the lip on the hopper gate. This metal projection drags through the coal in the feeder hopper and prevents the closing of the scale gate until all coal is below its lip. Since this addition no further difficulty has been experienced with the operation of the four automatic weight scales.

Pulverized fuel firing lends itself admirably to an industrial plant operating two shifts per day, five days per week. At the end of the second shift of each work day, one boiler is taken off because of insufficient load. With the dampers tightly closed the loss of heat allows a drop in pressure of 200 lb. in 4½ hr. It requires less than 1000 lb. of coal to put the boiler back in service at the commencement of the next shift. Either boiler can with one pulverizer, be fired up and put in service, from cold water to 675 lb. ga. pressure, in 20 min.

Coal vs. Hydraulic Power

THIS QUESTION involves not only comparative costs of supplying power to consumers but also the effect of displacing coal by hydraulic power on industries, railroads, employers and workers. In view of the threat to markets for coal by hydroelectric power which is advocated as "cheap," Appalachian Coals, Inc., a pioneer coal marketing agency in Cincinnati, presents the opinions of Thomas A. Edison, stated in 1929:

"First and best source of power is coal. We shall steadily require more power, but a great deal more fuss is being made over hydroelectric power than its intrinsic value warrants. Water power is a political issue, not a business one. The government never really goes into business, for it never makes ends meet. And that is the first requisite of business. It just mixes a little business with a lot of politics and no one ever gets a chance to find out what is actually going on."

J. E. Tobey, manager, fuel engineering division, Appalachian Coals, Inc., is of the opinion that users of electricity should find out what is actually going on. "There is a popular notion," he states, "that power from falling water costs little or nothing; that it is a free gift of Nature. That is far from the fact. Hydroelectric power involves the construction of huge dams, the creation of great storage reservoirs, the installation of expensive generating equipment, and last, but by no means least, the construction of transmission lines to move the electric power from the point of generation to the market for its distribution and sale. All of this means large capital investment. The cost of hydroelectric power to the user resolves itself into a question of dollars and cents.

"Power generated by coal-burning steam plants is also a dollars and cents question and capable of precise determination. Steam-generating plants are of much less capital cost than hydro power facilities. Steam-generating plants ordinarily may be located close to the point of distribution and sale, as in the case of Tennessee Electric Power Co. at Nashville, Tenn., which wants to build a steam plant rather than use TVA electricity. The major cost factor is easy access to coal.

"Couple modern efficiency of steam plants in generating electricity, with an abundant supply of coal and the elimination of current losses from long distance electric transmission, and the steam plant is the more economical nearly every time."

DESIGNED ESPECIALLY for photographing the internal structure of metals, the world's most powerful microscope is located in the Bell Telephone Laboratories in New York City. It was built to specifications laid down by the laboratory experts at the Zeiss works in Germany and is capable of enlarging about 7000 diameters. The study of metallic structures is important in telephone work, reports the New Jersey Public Utility Information Committee. Because of wide use of metals and the effect of stressing or flexing or vibration it is vital to know the metal structure suitability.

Combining Prime Movers

Diesels offer limitless possibilities for augmenting the output, improving the efficiency and increasing the reliability of steam and hydraulic plants

PROVIDING an adequate supply of power at the lowest possible cost is one of the major functions of the industrial power engineer. The task is often complicated by an additional demand for heating or process steam, which in some cases, is sufficient to dominate the final design.

The ideal setup is where all the power needed may be generated by back pressure service and the exhaust utilized for heating. This necessitates close agreement between the power and steam load curves which unfortunately is the exception rather than the rule. Often power peaks occur at times of minimum steam load so that a straight back pressure plant must, as a rule, waste steam to the atmosphere at some times and supply deficiencies at other times through a steam pressure reducing valve. The base electric load under such conditions is that corresponding to the minimum steam consumption.

Fortunately the modern engineer has equipment available to eliminate such losses. For small plants the steam engine may be used to advantage and may be arranged for straight back pressure, straight condensing or for extraction. Duplex engines may be operated with one side condensing the other noncondensing while compound engines may be arranged for bleeding from the receiver, a practice quite common in small European plants.

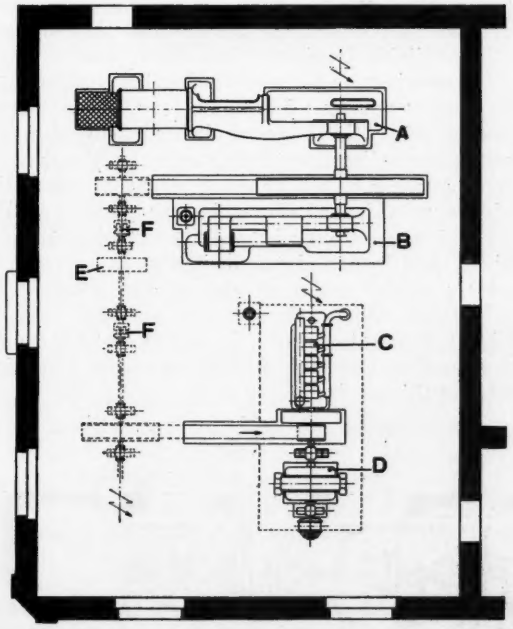


Fig. 1. Plan of a station using a combination of steam and Diesel engine. A is a 200-hp. steam engine, B an ammonia compressor, C a 200-hp. Diesel and D a 200-kw. d.c. generator. The shafting E, shown dotted because it is in the basement, incorporates two clutch couplings F

For larger plants, the extraction-condensing turbine is widely used all over the world and has been highly developed. In addition, water power when available cannot be neglected, the general low cost and availability always brings purchased power into the picture, while the record of the Diesel and gas engine is such as to demand detailed consideration. Properly designed waste heat installations for Diesels may be depended upon to furnish considerable quantities of low level heat, which unfortunately, is subject to the same limitations as a back pressure steam plant, that is, the heat available is a function of the power load.

Multiple units, combination steam and Diesel plants are no longer a novelty and the widespread use of electric power in which the two types of prime movers are coupled electrically, offers unlimited possibilities of expansion.

Such combined operation is not, however, limited to electric plants for oil engineers, steam engines and turbine, and water wheels may be mechanically coupled to form a single power unit. This is particularly useful in the case of smaller industrial plants not only to improve heat balance conditions but to give additional power and reliability.

Sulzer Brothers, Ltd., of Winterthur, Switzerland, has made a number of installations of that type in various parts of Europe. The three illustrations presented were engineered by them and may be considered typical of small plants where mechanically connected Diesels operate with steam engines, steam turbine or water wheels.

In general, the steam engine is regulated to work at a constant back-pressure, to provide all the heating steam that can be used while the Diesel engine provides the remainder of the power required. Since the Diesel engine has a higher thermal efficiency than the low-pressure condensing steam engine, the overall economy of the steam-Diesel set is higher than that of an extraction steam engine or turbine. Such an arrangement is both technically sound and satisfactory in service.

Figure 1 shows an example where the steam engine and the Diesel engine are coupled together mechanically. The existing steam engine drives a refrigerating compressor and line shafting. The Diesel engine has its own three-phase generator, which is large enough

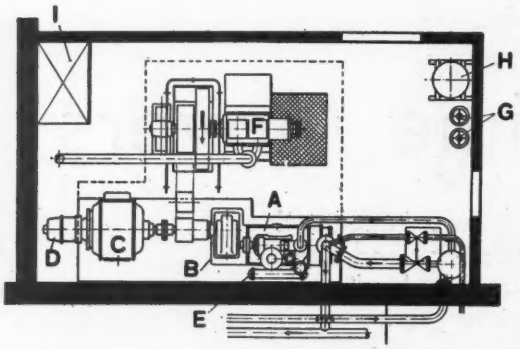


Fig. 2. In this plant a steam turbine and a Diesel make an interesting team. The electric generator C and direct connected exciter D are driven by a steam turbine A through the gear B, and, by a two cylinder Diesel engine F through a belt. E is the oil cooler for the turbine while G and H are the starting air bottles and fuel tank, respectively, for the Diesel. I is the switchboard

to take additional load from the steam engine. Power from the steam engine is transmitted to the generator by means of shafting under the floor of the engine room. The steam engine works as a pure back-pressure engine and the power developed by it, which varies in accordance with the fluctuating demand for heating steam, is used to drive the refrigerating compressor and the three-phase generator. The Diesel engine provides any additional energy that is required.

A combination of Diesel engine and steam turbine is shown in Fig. 2. Here also the two machines are coupled together mechanically, the steam turbine driving the three-phase generator through a reduction gear and the Diesel engine working through a belt on the same shaft.

An installation in which the Diesel engine is added to an existing hydraulic turbine plant as an additional source of power is to be found in a cotton mill in Switzerland and shown by Fig. 3. The Sulzer Diesel engine, which is clutch coupled to two Pelton wheels, develops 300 b.hp. at 300 r.p.m., and is used for supplying the standby and peak energy required when little water is available. The turbine wheels are direct coupled to an electric generator and they also drive shafting through a belt.

Of course electrical rather than mechanical connection is sometimes advisable and an interesting example of this type is a plant recently installed in a brewery in the South of France. The brewery owns a Sulzer two-cylinder extraction steam engine developing about 600 b.hp. Steam was expanded in the high-pressure cylinder from boiler pressure to heating-steam pressure, while the low-pressure condensing cylinder originally took from the receiver varying quantities of steam not used for heating. A Diesel engine, interconnected with the high-pressure and low-pressure cylinders of the steam engine was installed to relieve the low-pressure cylinder of the responsibility of balancing the steam and power loads. The combined plant works as follows:

The high-pressure cylinder of the steam engine develops as much power as possible from the steam required for heating. When the demand for electric energy increases the Diesel engine through the governor of the steam engine automatically picks up the load. Only after the Diesel engine develops its maximum output is steam allowed to pass into the low-pressure cylinder of the steam engine. With decreasing load, the low-pressure cylinder of the steam engine cut out first and then the Diesel engine carries the load swings. The steam engine and the Diesel engine each drive a three-phase generator, the two generators being paralleled electrically, thus completing the connection between the steam and Diesel engine.

Regulation of such combined units is important but it is quite impossible to lay down definite rules for procedure. Generally, the more powerful prime mover is arranged to take care of speed regulation. In back pressure steam installations the ideal system of regulation embodies a speed governor on the Diesel or hydraulic turbine, and, a pressure regulator on the steam end, so that the steam flow is determined by the heating load.

In certain cases, however, the steam unit must be provided with speed regulation as well. This is the case in the last plant mentioned, the brewery in Southern France. The problem of operating two or more units in parallel with speed governors is a common one all over the world and is a matter of proper governor characteristic design.

Convenience and necessity demand that some means be provided for separating the units so that one unit may be available for inspection and repair while the other is running, or to prevent friction and windage losses when one unit can handle the load. In electrically connected plants this is accomplished easily by means of switches and disconnects. In mechanically connected units a coupling clutch or some means of separation should be provided as shown by the clutch coupling F of Fig. 1, the coupling between the turbine and gear of Fig. 2, and by the clutch E of Fig. 3. The belt between the engine and generator of Fig. 2 serves the same purpose. As a rule it is not essential to use a clutch which can be thrown in or out while the plant is in operation although special operating conditions may make this advisable.

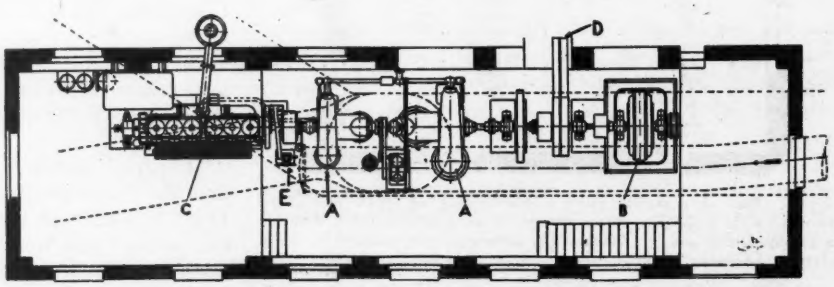


Fig. 3. A Diesel may also help out hydraulic turbines. The two turbines A normally drive the direct connected generator B and a line shaft (through belt D) but are helped over peaks and periods of low water by the 200-hp. Diesel C which is connected to the shaft extension by the clutch E

PART I—Cleanliness, adequate lubrication, good design and proper clearance is the secret of success with gas and Diesel engine piston rings. The first part discusses the general factors of piston ring selection and deals specifically with compression rings. The second part deals with oil rings and the importance of proper clearance.

Cylinder wall well polished by properly fitted and selected piston rings

PISTON RINGS for DIESELS

By E. STEAD

Chief Engineer, American Hammered Piston Ring Div., Koppers Company, Baltimore, Md.

WHEN INSTALLING a new set of piston rings in a Diesel engine, the operator is primarily interested in obtaining the best possible performance from the rings. Some part of the successful functioning of the new rings will depend upon such factors as the design and past performance of the engine, but these may be said to be like heredity and early environment in a man's life. No matter how important they may be, they must be accepted just as they are and efforts to attain success in the future must be concentrated on other factors—factors which are within our control.

Some of the most easily controllable factors affecting the life of piston rings are the clearances with which the rings are fitted. A few years ago it was considered good practice to fit rings with practically no clearance, the theory being that the clearances would increase with time. This is true if the rings do not become jammed or stuck before they have had a chance to loosen up. So much trouble was experienced when that practice was followed, however, that it has been generally abandoned and the avantages of good, generous clearances are becoming more and more universally recognized.

Perhaps the next most easily controllable factor is cleanliness. Failure to take every precaution in regard to cleanliness in overhauling, periodic cleaning and general operation may be compared to reckless driving among motorists. We see plenty of evidence of it, but never find anyone who admits being the guilty party—it is always the other fellow. This is particularly noticeable after reboring cylinders. Everyone knows that chips or other particles which remain when the engine is reassembled will shorten the life of the rings and will greatly increase cylinder wear. Generally this is carefully watched, but occasionally it is missed. Therefore, after thoroughly cleaning all parts of the assembly, it is best to repeat the process and clean them thoroughly again and again before assembling because small pieces of abrasive are hard to remove even with several cleanings.

The term "cleanliness" may also apply to the use and care of centrifuges and air-filters. Carbon or other foreign matter in the oil and dust in the air will not only promote wear but will also tend to cause rings to stick in their grooves. This question of

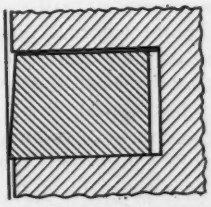


Fig. 1. The tapered compression ring seats quickly even when the cylinder is out of round

ring sticking has recently been the subject of several investigations, one of which[1] indicates that we are on the threshold of the development of alloyed or compounded oils which hold great possibilities for the avoidance of ring sticking.

Lubrication is, only to a certain extent, dependent on the design of the engine. Outside of this limitation it is entirely within the control of the operator and no other factor in his control has such a vital effect on the life of the piston rings. It has often been pointed out that piston rings and cylinder lubrication are dependent upon one another. If the lubrication fails, the piston rings are doomed. On the other hand, if the rings fail by not holding compression satisfactorily and thus permitting blowby, they are committing suicide. The hot gases blowing past them from the combustion chamber will destroy the rings. At the same time, the cylinder and piston will also be seriously damaged.

Choice of the particular type or types of rings to be used is one of the main factors in which the operating engineer can use his judgment in controlling the performance of the engine. A variety of piston rings are used by different engine builders for original installation. The majority of these are one-piece rings —plain compression rings and beveled scraper rings, but quite a number of builders are adopting special types of rings for original installation because it is realized that, if blowby can be held to a minimum from the very start of operation, the rate of cylinder wear will be greatly reduced. Similarly, if more efficient oil control rings are used from the start, it is not only possible to reduce wear by keeping more oil on the cylinder walls but also to control it more efficiently so that while a more abundant supply is available for lubrication, the excess is held down by the rings and prevented from reaching the combustion chamber.

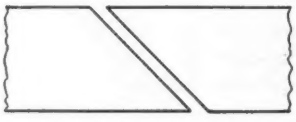


Fig. 2. With the plain angle joint the leakage area increases as the rings wear and tend to straighten out

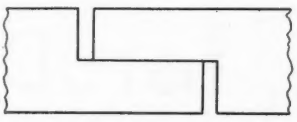


Fig. 3. The step joint does not necessarily reduce leakage because a path is completed by the clearance back of the ring

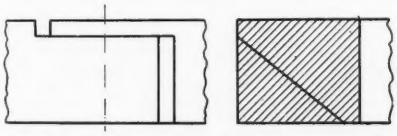


Fig. 4. This step seal ring is one of the simplest types designed to reduce gas leakage through the joint

Compression Rings

One of the simplest modifications of the plain compression ring is the tapered ring shown on an exaggerated scale in Fig. 1. In actual practice the taper on the outside bearing surface of the ring is about 2 deg. Having a very narrow bearing surface, the ring seats in around its lower edge almost immediately, even in cylinders which are somewhat out of round. It therefore prevents the initial damage caused by blowby at any point where a plain ring may not be able to conform to the cylinder, because of irregular wear or distortion by heat. After the lower edge of a tapered ring has seated, the width of bearing surface gradually increases, assuring a gradual seating in which results in a high polish on the rings. This polish greatly reduces the rate of wear after the rings have become completely seated across their entire width. In this connection, it might be well to note that a ring which has become well polished in service will be found to wear extremely slowly whereas a ring which has a dull appearance due to score marks on its bearing surface, will be found to wear far more rapidly. A well polished cylinder acts in the same way as a well polished ring in reducing the rate of wear.

Another modification of the one-piece ring which forms a seal quickly around its entire circumference while coming gradually to a complete seat across its face width is the gold seal ring which has one or more bronze bands inserted in the bearing surface. The bronze bands, being relatively soft, not only enable the rings to seat in gradually but also help to polish the cylinder and still further reduce the rate of wear throughout the entire life of the rings.

In relatively high speed engines, joint leakage is generally not serious if the cylinders are true to shape because the opening at the ring joint is an extremely small percentage of the total circumference. After some wear has taken place and the cylinders are tapered, however, the joints open up when the rings are in the larger part of the cylinder so that the leakage through the joints becomes more serious. With the plain angle joint, as shown in Fig. 2, there is, of course, a straight path for leakage through the joint of the ring. With the step joint, as shown in Fig. 3, the path is not straight but there is practically no reduction in leakage because gas entering through the upper part of the joint can pass into the space in the piston groove behind the ring and out through the lower part of the joint. Numerous types of rings have been designed to overcome this. One of the simplest of these and, therefore, one which is least likely to be made inoperative by carbon formation, is the step seal ring shown in Fig. 4. The construction of this ring is such that leakage cannot occur through the lower part of the joint because of the seal which is formed by the joint across the lower face of the ring.

Multiple-piece rings generally have joint seals. They also are more flexible than one-piece rings and so more capable of conforming to badly worn cylinders. Whenever they are used, it is recommended that they be placed in the lower compression ring grooves where they are better protected from breakage and carbonization than in the upper grooves. Some types of multiple-piece rings are designed to prevent the joints of the rings from springing outward into ports in the cylinder so that they may be used without pinning in two-cycle engines. In fact, in engines which have relatively short ports, even one-piece rings are being used without pinning. If the ring joints are well chamfered, it is generally found to be entirely safe to omit pinning if the maximum individual port opening is not more than 22 deg.

(To be concluded)

[1] S. A. E. Journal, March, 1937, by C. G. A. Rosen of the Caterpillar Tractor Co.

DUAL FUEL DIESEL Sets Record

In service 98.5 per cent of the elapsed time, for 9 mo. new Nordberg engine operates on gas at a fuel cost of 1.72 mills and a lubricating oil consumption of 5483 hp. hr. per gal. Burns gas or oil on Diesel cycle. Conversion involves no major changes in engine. Spark ignition of gas eliminated

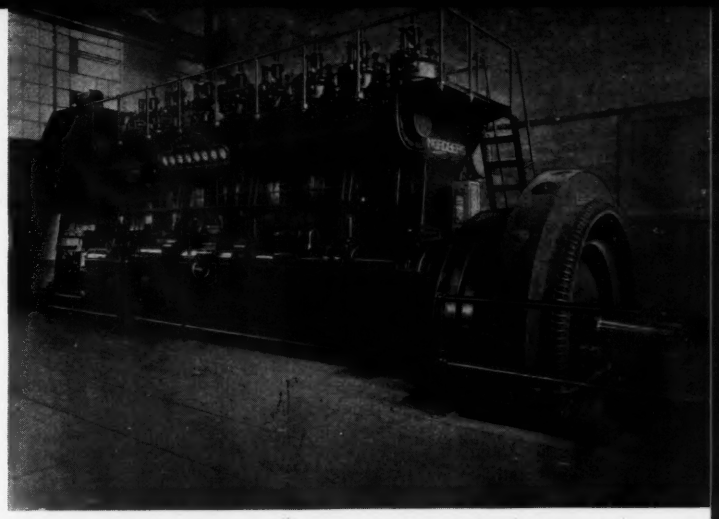


Fig. 1. An eight cylinder, two cycle, 1500 hp. Nordberg Dual fuel engine at Lubbock, Texas. Burning oil it operates as an air injection engine. When burning gas the fuel pumps are used to actuate the fuel injection valves, while the gas is delivered at 1100 lb. pressure by the high pressure compressor. Stable operation is maintained by a small oil pilot

CONVERTIBLE ENGINES, capable of burning either gas or oil, have been developed of recent years to meet a definite need for prime movers that could take advantage of low gas rates yet be provided with standby fuel at reasonable cost to take care of emergency conditions or limited gas supplies and give the desired independence from a single fuel supply.

Conventional 4 cycle gas engines operating on the Otto cycle with a compression ratio of 5.5 to 6.5 are not built heavy enough to operate as a Diesel with compression ratios that may run as high as 16. Built as a Diesel, however, an engine may be converted to a gas engine by substituting an ignition system and gas mixing valve for the oil fuel pump and injection nozzles and changing the heads or pistons so as to give the proper compression.

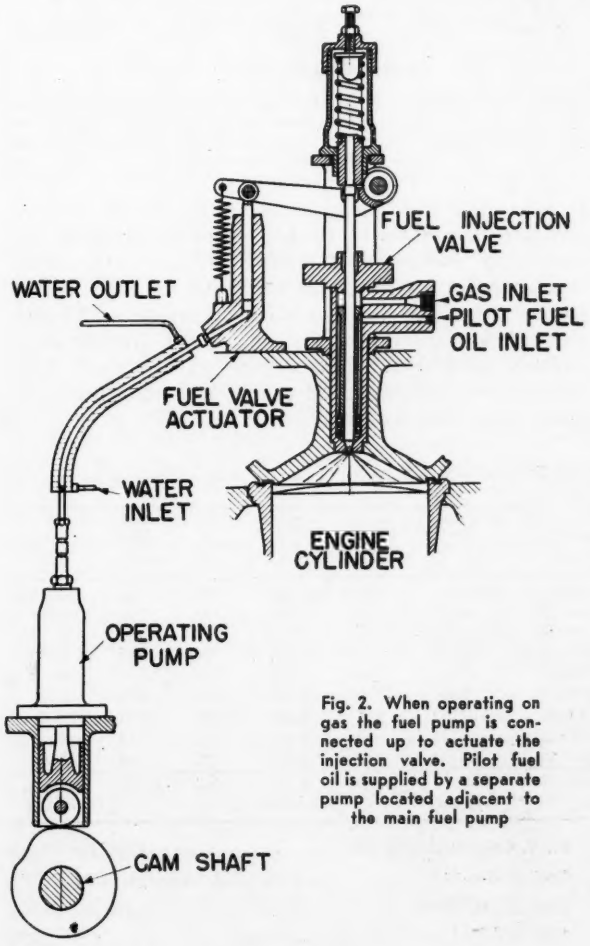


Fig. 2. When operating on gas the fuel pump is connected up to actuate the injection valve. Pilot fuel oil is supplied by a separate pump located adjacent to the main fuel pump

By designing the engine so that these changes may be made easily a number of manufacturers have developed highly successful engines, some of which it is claimed may be converted from one fuel to another in half a day's time. When operating as a gas engine on the Otto cycle, the limiting efficiency is, however, lower than when operating as an oil engine on the Diesel cycle.

Efficiency on either cycle is a function of both the compression ratio, r, and the ratio of specific heats, γ, of the working substance and may be expressed by the equation

$$E = 1 - \left[\frac{1}{r}\right]^{\gamma - 1}$$

For air, γ is 1.408 and this forms a convenient basis of comparing cycles even though in practice the value probably lies between 1.30 and 1.35 so actual cycle efficiencies are lower than calculated from the air standard. The influence of compression, the ratio of the initial to final cylinder volume, is greater, ranging from an efficiency of zero at a compression ratio of 1 to 100 per cent at infinity.

When the fuel is introduced with the air as in a conventional gas engine, the compression ratio is limited by the self-ignition temperature of the fuel. It ranges from 5.5 to 6.5 for different kinds of gas. For ordinary gasoline it is about the same but by proper doping the limit may range up to 10. For a Diesel or compression ignition engine the ratio may be extended to about 16. Using the equation above it is a simple matter to calculate the limiting cycle efficiency of about 52 per cent for a compression ratio of 6 whereas the efficiency increases to about 67 per cent for a ratio of 15. Above this the curve flattens out so that the gain in efficiency is more than offset by the cost of the

heavy construction needed to withstand the high pressure.

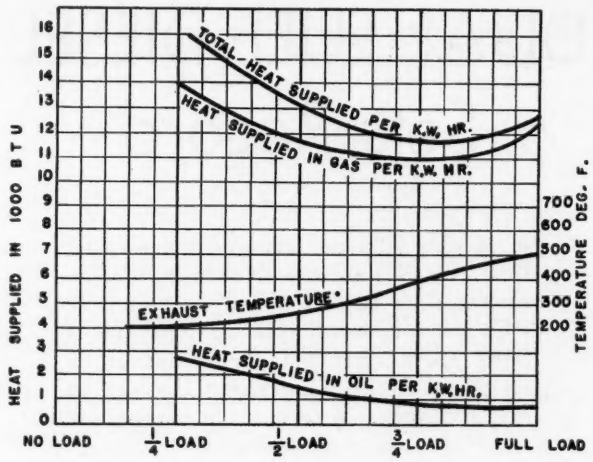
This limited gas efficiency of the conventional convertible engine has been overcome in the new 2 cycle dual fuel engine developed by the Nordberg Mfg. Co. and which operates with either fuel on the Diesel cycle. When operating as a gas engine, the fuel is injected at the top of the compression stroke just as in the case of oil and no spark ignition is necessary. Conversion from one fuel to another involves no major changes but the engine rating is reduced by about 10 per cent.

Although the principle may be applied to either air or mechanical injection Diesels, the first engine to be put in commercial operation is a standard Type TA, 17 by 25 in., eight cylinder, air injection crosshead type engine with a built-in scavenging pump and superimposed 3 stage injection air compressor. It is equipped with a Woodward governor and Bosch fuel pumps and is direct connected to a 1250 kv.a., 60 v., 3 ph. 60 cycle General Electric generator.

With oil as a fuel, injection valves are operated by push rods from a cam shaft and governing is by means of a by-pass on the fuel pump. With a gas as a fuel, operation is practically the same except that the three stage compressor handles gas, the injection valve push rods are disconnected and the fuel pumps hooked up as shown by Fig. 2 to actuate the fuel injection valve. The governor operating the bypass on the operating pump determines the duration of the injection valve opening and the amount of gas injected into the cylinder.

In order to obtain smooth operation and uniform combustion at all loads, a small amount of fuel oil, indicated as "pilot fuel" on Fig. 2, is injected with each charge of gas, and this together with certain features of the control system, are covered by patents. Inasmuch as the total fuel input will be greater than the input of pilot fuel, the oil injection is limited to a quantity somewhat less than that needed for no load operation. Although the quantity may be varied with load, simplicity of the control makes a constant injection desirable. On the Lubbock engine this amounts to 34.86 lb. per hr. at all loads.

This engine was placed in operation in 1936 and in the 9 mo. from September, 1936, to May, 1937, was in service 6462 hr. or 99.6 per cent of the elapsed time.



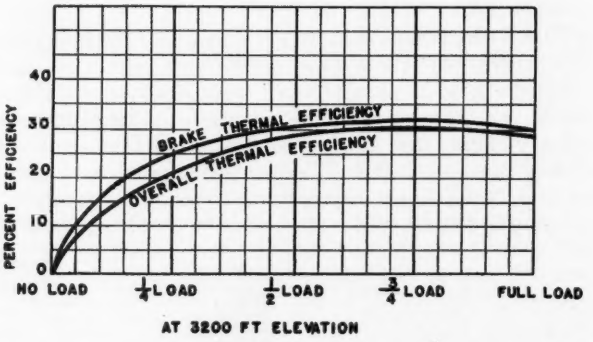


Fig. 3. Test performance of the 1500 hp. unit at Lubbock. Nine months' operation showed an average performance of 11,670 B.t.u. per kw. hr. generated, an overall thermal efficiency of almost 30 per cent. Lubbock is 3200 ft. above sea level

It generated some 4,886,400 kw-hr. at a fuel cost of 1.72 mills, as shown by the accompanying table and at an average fuel input of 11,670 B.t.u. per kw-hr. This is a saving of some 46.2 per cent over the 3.2 mill fuel cost of the Diesels in the station operating on 3.1 cent per gallon oil, but these costs are not directly comparable because the new engine was operated base load with an average load of 757 kw. while other engines took the load swings.

Operating record for 9 mo. during which the average load was 757 kw. The pilot oil fuel is constant at a rate of about 34.86 lb. per hr.

Date 1936-37	K.W. Hours Generated	Gas Used 1000 Cu. Ft.	Gas Cu. Ft. Per K.W. Hr.	Cost of Fuel: Gas	Cost of Fuel: Pilot Oil	Cost of Fuel: Total	Fuel Cost Per K.W. Hr.	Gals. Lub. Oil Used	Engine H.P. Hrs. Per Gallon	No. of Hrs. Run	No. Hrs. In Month	% Hrs. On Line
Sept.	535,700	5,813	10.88	$831.50	$133.36	$964.86	$.00180	216	4,920	708	720	98.25
Oct.	553,600	6,101	11.02	844.54	139.68	984.22	.00178	192	5,780	742	744	99.75
Nov.	528,100	5,831	11.03	803.50	135.24	938.74	.00178	186	5,790	718	720	99.75
Dec.	560,800	6,277	11.20	816.01	139.20	955.21	.00171	193	5,740	739	744	99.50
Jan.	535,700	5,912	11.03	768.56	134.10	902.66	.00169	186	5,750	713	744	96.0
Feb.	503,200	5,383	10.70	699.79	125.45	825.24	.00164	179	5,580	666	672	99.5
March	560,600	6,122	10.92	795.86	139.20	935.06	.00167	211	5,250	739	744	99.5
April	547,800	6,175	11.38	802.75	134.80	937.55	.00172	198	5,420	715	720	99.5
May	560,900	6,321	11.29	821.73	136.00	957.73	.00171	212	5,120	722	744	97.0
TOTAL	4,886,400	53,935	11.05 average	$7,184.24	$1,217.03	$8,401.27	$.00172 average	1,773	5,483 average	6,462	6,552	98.6 average

Total K.W. Hrs. Generated 4,886,400
Total Cu. Ft. Gas Consumed 53,935,000
Average Cu. Ft. Gas per K.W. Hr. 11.05
B.T.U. Content of Gas ..... 975 per Cu. Ft.
B.T.U. Content of Pilot Oil ..... 19,200 per Pound.
Cost of Gas ..... 13 to 14 Cents per 1000 Cu. Ft.
Cost of pilot Oil ..... 4 Cents per Gallon.
Total B.T.U's. per K.W. Hr. Generated 11,670

Flames and Combustion

Clarity of Flame is a Practical Guide to Efficiency of Combustion

By A. BEMENT

IT IS HELPFUL, in dealing with the combustion process, to consider the matter from the standpoint of the combustion of the flame that arises from the burning fuel as a separate process from that of the fuel on the grate. Thus two distinct and separate processes are involved in burning the fuel in the furnace.

The material that produces flame is that combination of carbon and hydrogen known as hydro-carbon. Carbon in a free state is a solid, a black material. In combination, the heat of the furnace not only drives this hydrogen compound from the coal on the grate, but also acts to break up the combination of the carbon and hydrogen. Owing to this action, carbon appears in the flame as a minute solid particle and the hydrogen as a gas. As the ascending gas body, or flame producing material, is heated, either from the heat of the fire or by the combustion in the flame itself, these carbon particles become luminous for a brief instant. It is this luminosity that gives that quality that is known as flame.

While carbon plays the leading role in flame production, a considerable amount of CO may be contributed from the solid fuel on the grate, as well as hydrogen from the breaking up of the hydro-carbon combination. While these elements in burning give no illumination, their combustion proceeds as the carbon of the flame burns.

The moment that the hot carbon particle comes in contact with oxygen, it changes from a solid condition to that of gas as CO_2, or in case of lack of sufficient oxygen it may combine as CO, a colorless gas.

If all of the carbon particles could at once come in contact with oxygen, there would be no visible flame. That this is a fact has been experimentally demonstrated. In this instance combustion of bituminous coal was produced with 19 per cent CO_2 with no appearance of flame at all. The furnace and fuel bed were at an intense incandenscence and every piece of the burning fuel was visible. Therefore, if oxygen should come in contact at once with these carbon particles, there would be no apparent flame.

Flames are masses of gas to which air in large measure does not find entrance. Thus flames burn largely on the outside surface. Therefore, the problem is facilitated if the flames produced be short or small ones, rather than long or massive ones. For example, the underfeed type of stoker produces relatively short flame as flame combustion, in considerable measure, takes place within the fire of the fuel bed.

Combustion chambers play a leading part in facilitating flame combustion. If sufficiently ample, there would be opportunity for any flame mass to burn out before contact with cooling surfaces of the boiler.

Combustion chamber capacity available, however, in some conditions cannot in itself be sufficient. Such situations suggest the desirability of producing short flames if feasible. For example, the usual natural draft chain-gate is quite deficient in combustion chamber capacity. Such conditions may be overcome by a steam or air jet blowing across the furnace at the front, a little above the entering fuel, in this way mixing air and gas together so that flame combustion is effected at once.

Forced draft chain grate stokers present an especially serious problem because of the reduced air supply to the rear portion of the grate, as this limits the amount of air that might enter at this point to contact the flame in the combustion chamber. The best solution for such a case is that of air blown in through a number of openings across the front of the furnace by means of a power fan. This scheme has come to be known as "over fire air" supply.

These two cases of the chain-grate stokers afford illustration of methods of producing short flames that demand minimum service from the combustion chamber.

Pulverized coal firing demands ample combustion chamber space, as the flames produced are long and massive.

Eye Protection for Firemen

BOILER room employees exposed to fire box conditions in checking fires are subjected to the hazards of visible and invisible light rays set up by these fires in combustion chambers. They are also handicapped by visible light glare of the temperature of these fire boxes which put them at a disadvantage when turning away from the glare of the fire box in making observations of water columns and steam gages.

To overcome both of these conditions, that is, the hazards of injurious invisible light rays and glare, T. A. Walsh, safety engineer of the American Optical Co., recommends to the National Safety Council that such men be provided with a filter glass that will absorb the injurious invisible light ray and reduce to a practical degree the intensity of the glare necessitating them to make observations away from the fire boxes more quickly and safely. In many of the power stations in the country, such a glass is used in spectacle goggle form by the boiler room operators.

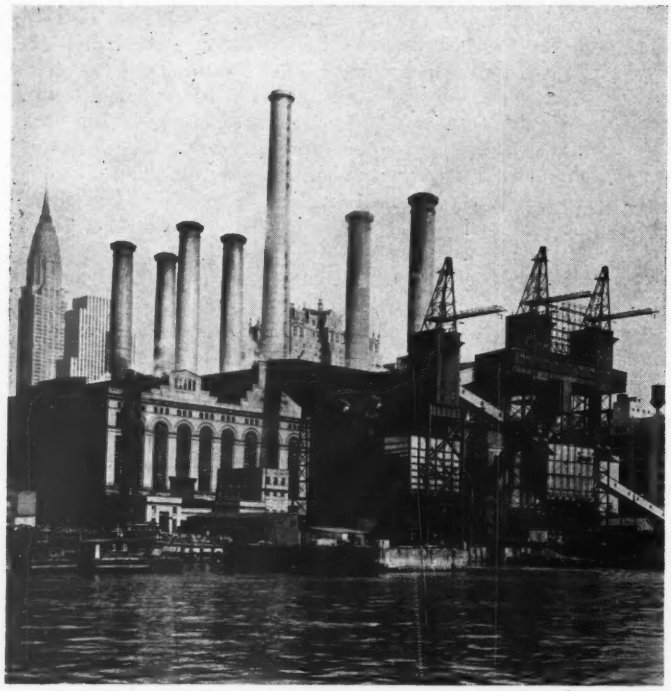
Practical tests have brought out that a good welding glass of a number six shade is most efficient for use in power plants operating stoker fired boilers or where oil is used. On some gas fired boilers and on pulverized fuel, denser glass has been found more satisfactory. On the lower pressure boilers the use of a lighter glass on the part of the operators is frequently resorted to. In all cases, however, the glass used should be of a good welding or filter glass quality. By using such a glass, you will obtain the highest absorption efficiency in the injurious light created by the fires under the boilers and through a selected shade will be able to give the man a protection against the glare and assist him in making his observations inside the fire boxes more efficiently than with the naked eye or as frequently used an ordinary piece of blue glass.

WATERSIDE

By H. KNECHT, Division Engineer, Turbo-Plant Equipment

By M. A. GUIGOU, Division Engineer, Mechanical Design

CONSOLIDATED EDISON CO. OF N. Y., INC.
New York, N. Y.



Waterside Station has played an important part in New York's power supply since the turn of the century and is being modernized by a revamping program scheduled for completion in 1950.

TO MEET the rapidly growing demand for 60 cycle electric supply in central Manhattan, the Consolidated Edison Co. is placing in operation, at its Waterside Station, a high pressure turbo-generator which is the initial step in the complete modernization of this station. This project will involve the retirement of eight vertical turbine generators, having an aggregate capacity of 114,000 kw., ninety-two 35,000 lb. per hr., 200 lb. boilers together with their associated auxiliary equipment and the installation of eight boilers, each having a capacity of 500,000 lb. of steam per hr. at 1400 lb., 900 deg. F., four 53,000-kw., 1200 lb., 900 deg. F. turbine generators exhausting at 200 lb. and one 50,000-kw., 200 lb. condensing turbine generator.

Coincident with the installation of this new equipment, 250,000-kw. of 200 lb., 25 cycle turbine capacity will be gradually rebuilt for 60 cycle operation. The progress made to date on this program is: One high pressure unit installed, a second unit on order, and three 200 lb. units having an aggregate capacity of 70,000 kw. at 25 cycles rebuilt for 80,000 kw. at 60 cycles. While the use of topping turbines has become quite general and the fundamental principles involved are largely the same in all installations, due to local conditions each station presents many individual problems in the adaptation of existing structures and equipment to new uses. As an illustration in point the unusual heat balance arrangement at this station was largely influenced by the fact that the topping turbines and the low pressure units which will use the bulk of their exhaust are about 400 ft. apart.

From Fig. 2 it will be seen that the Waterside Station consists of two plants separated by East Thirty-ninth Street but tied together by numerous steam, water and electrical lines, making possible the operation of these two plants as one unit. The high pressure boilers and turbines are located in Waterside No. 2, whereas the bulk of the low pressure turbine equipment is in Waterside No. 1. These low pressure turbines are provided with steam driven auxiliaries and are of a type not easily adapted to extensive bleeding. It was consequently desirable so to arrange the heat balance of the station, Fig. 1, that the exhaust steam from the turbine auxiliaries in Waterside No. 1 could be used for the initial step in feedwater heating before returning the turbine condensate to Waterside No. 2. In order to secure adequate deaeration of the feedwater at all times it was necessary to provide a source of steam at a suitable pressure for this purpose which would be adequate at all times, regardless of the load on the high pressure turbine. After considering numerous means of meeting this condition, it was decided that a feed-heating turbine of the main generator shaft met the requirements at a reasonable cost and with a minimum complication to operation.

The first turbine now being installed, Unit No. 4, is a 53,000-kw. 3600 r.p.m. Westinghouse machine, a cross-section of which is shown in Fig. 4. The main section has a single Curtis stage and 14 reaction stages and the feed-heating section a single Rateau stage and 19 reaction stages. At full load the main section contributes 49,500 kw. and the feed-heating turbine 3500 kw. The sealing arrangement is of the Westinghouse axial type with provision for longitudinal adjustment of the spindle after the turbine is loaded to reduce sealing steam and stage leakage. A motor driven turning gear is provided for use during periods of short shut down. Figure 3 shows this unit being erected.

First of the problems encountered on this installation was the foundation design. Due to a narrow turbine room the width of the foundation was restricted to approximately 11 ft., and, due to the desirability of a continuous one level turbine operating floor for the new

INSTALLS A TOPPING TURBINE

After thirty-five years of operation at 200 lb. pressure, vertical turbines are removed to make way for 53,000-kw., 1200 lb., 900 F. unit. Location at heart of Manhattan's load center is an important factor in Waterside's history

installation and vertical space allowance for a low pressure condensing unit, the height of the foundation became 33 ft. The length of the machine, 60 ft. approximately, governed the length of the foundation. Because of the unusually high ratio of height to width, the steel in the foundation was designed with a low fiber stress and was heavily braced to reduce girder deflection to a maximum of 0.02 in. The foundation is massive and every means was employed, including addition of concrete where possible, to obtain rigidity. Concrete footings for the columns on one side of the turbine foundation had to be sunk to a depth of 30 ft. to rock due to the existence of water tunnels below the basement floor.

The governing system is full hydraulic, oil actuated type. In addition to the usual speed responsive and emergency tripping elements a back pressure control is provided on the main turbine exhaust to limit back pressure to a predetermined maximum in the event of the disturbed conditions in the 200 lb. system. Operation will normally be at fixed load on the high pressure turbine, pressure control on the 200 lb. steam lines being maintained by the operation of the low pressure boilers. An electrical load limiting device is also included to avoid overload of the generator if the pressure in the 200 lb. mains falls below a predetermined limit.

Seven control valves are operated by the governor through a walking-beam and bar-lift arrangement, a recent Westinghouse development. This consists of a horizontal bar inside the steam chest, supporting valve stems of definite length so that raising the entire bar vertically results in sequential opening of the valve ports. Steam is admitted to the high pressure turbine through an inverted type throttle valve with the oil operating cylinder attached to the bottom of the valve

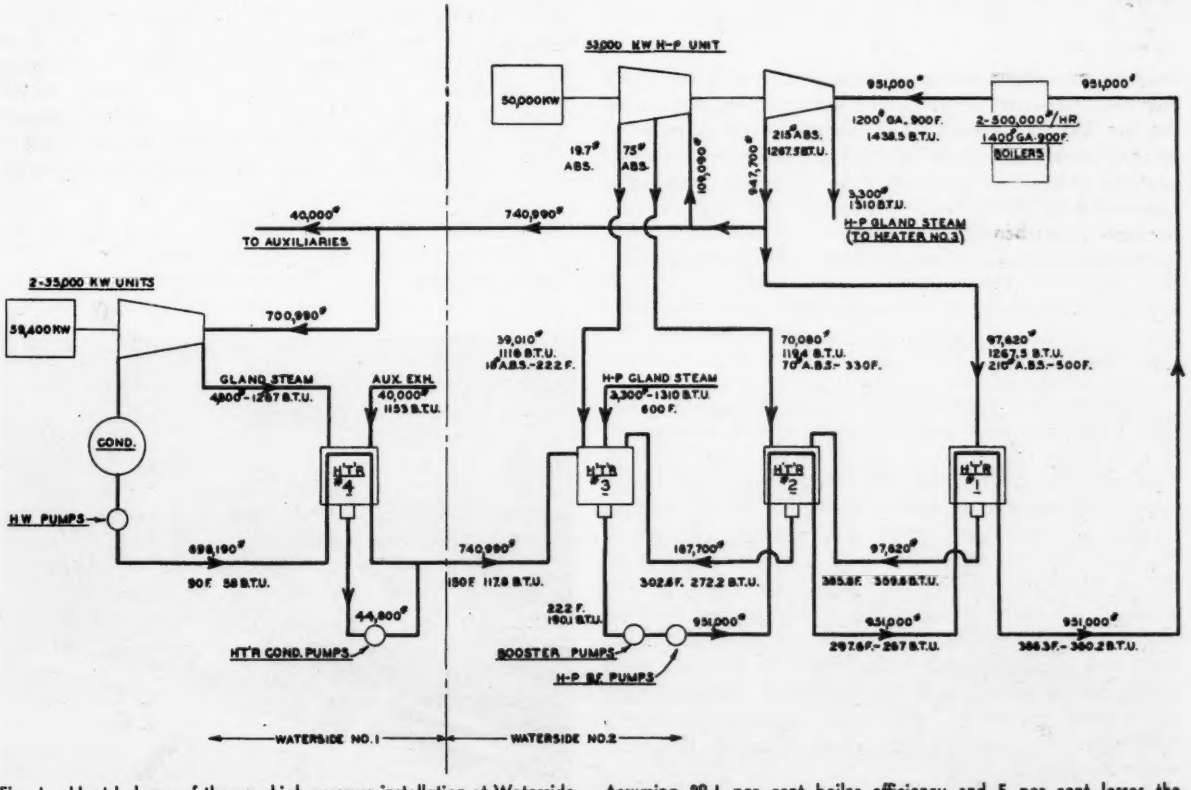
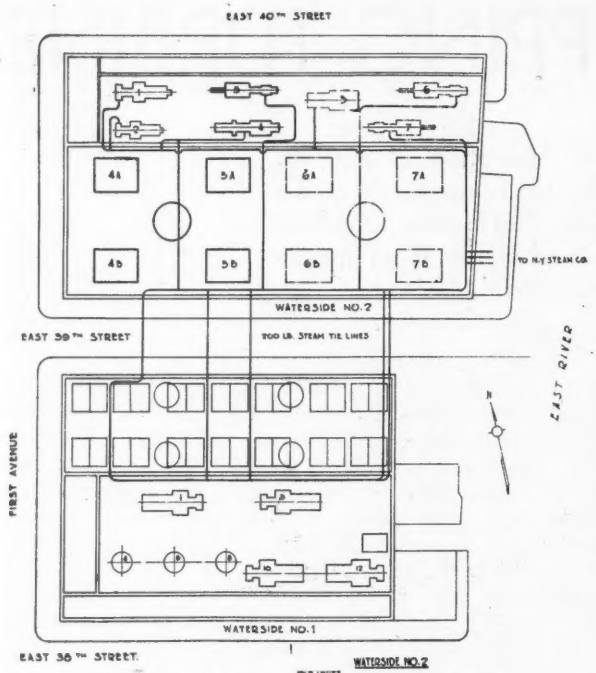


Fig. 1. Heat balance of the new high pressure installation at Waterside No. 2 for a load of 50,000 kw. on the high pressure turbine. After allowing 4850 kw. for auxiliaries the total net output is 104,550 kw. Assuming 89.1 per cent boiler efficiency and 5 per cent losses the calculated heat rate is 11,560 B.t.u. per net kw-hr.



WATERSIDE NO. 1

UNIT NO	ORIGINAL CAP. 25~ K.W.	REWOUND CAP. 60~ K.W.	APPROX. DATE OF INSTALLATION OR REWINDING
1	35,000	40,000	1950
3	35,000	40,000	1950
4	20,000	20,000	19
6	20,000	20,000	1937
8	20,000	20,000	1937
10	35,000	40,000	1950
12	35,000	40,000	1950

WATERSIDE NO. 2

OLD UNITS UNIT NO.	ORIGINAL CAP. 25~ K.W.	REWOUND CAP. 60~ K.W.	APPROX. DATE OF INSTALLATION OR REWINDING
1	30000	40,000	1935
2	22000	30,000	1939
NEW UNITS	STEAM PRESS.	CAP. 60~ K.W.	
3	200 LBS.	50,000	1942
4	1200 "	53,000	1937
5	1200 "	53,000	1936
6	1200 "	53,000	1939-40
7	1200 "	53,000	1942

Fig. 2. Plan of Waterside Stations after completion of the revamping program

body so that any possible oil leakage will be away from any high pressure piping. This arrangement eliminates the fire hazard present when the operating cylinder is located above the valve. Steam admission to the feed-heating section is controlled by a speed responsive governor which is also controlled by an exhaust pressure regulator. This governor operates seven control valves for admission of steam to the feed-heating section.

Turbine Oil System

Turbine oil system is divided into three parts. The first, a so-called high pressure oiling system is supplied by the main oil pump mounted on the turbine shaft and operates the throttle valve and steam inlet valve bar-lift mechanism, as well as providing oil for bearing lubrication, governors, trips and exhaust regulators. Oil from this system is also used for operating the oil driven hydrogen sealing oil pump. A steam driven auxiliary oil pump supplies this system during starting and shut down periods. A separate supply of oil for the generator hydrogen seals is furnished by the oil driven pump mentioned above. This system is provided with a separate reservoir baffled for releasing entrained hydrogen. A motor driven pump supplies the seals when the unit is down.

For bearing lubrication when the turning gear is in operation a separate motor driven pump is furnished. This pump is also arranged to cut in and furnish oil for lubrication while the machine is being shut down if for any reason the steam driven unit should fail to operate normally.

For maintaining the required purity of hydrogen within the casing and eliminating all possibility of fire or explosion due to the use of this cooling medium, the generator has been provided with an elaborate system of automatic safeguards. A separate control panel is provided for automatic compensation for the slight continuous hydrogen loss. This control also provides for the initial charging of the hydrogen system. In starting with the casing filled with air, carbon dioxide is introduced to displace the air, after which the carbon dioxide is in turn displaced by hydrogen. In normal operation a slight positive pressure is maintained continuously within the casing so that air infiltration is reduced to a minimum. Pressure gages, hydrogen purity indicators and alarms insure that the operator is familiar at all times with the conditions inside the generator casing and is warned of any unusual circumstances. In addition to these precautions against the development of explosive mixture, the casing has been designed to stand an internal pressure of 100 lb. per sq. in., 25 per cent higher than the maximum pressure which might be developed through the explosion of a perfect mixture of air and hydrogen within the generator casing.

Inside the generator casing, the cooling system consists of two fin tube coolers located in the upper part of each end of the generator housing. In order to eliminate the possible hazard of salt water leaks within the generator and the necessity for a shutdown of the unit for tube replacement, distilled water is circulated in a closed system through these coolers in series with a salt water heat exchanger. An emergency city water cooling supply is introduced into the distilled water circuit in the event of failure of the distilled water pump. An unsafe rise in temperature due to such a failure automatically opens an electrically operated valve to introduce enough city water for maintaining the desired hydrogen temperature.

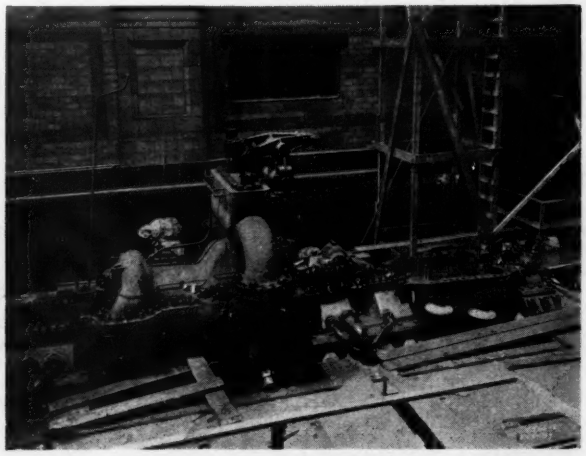


Fig. 3. The new 50,000-kw., 3600 r.p.m. turbine being installed in the station. The different parts may be identified by referring to Fig. 4.

Hydrogen Cooling

Hydrogen cooling for the generator improves the overall efficiency of the machine ½ per cent or more and in the present instance also effected a saving in external piping and ducts by the use of internal generating fans, suitable with hydrogen cooling but not feasible of installation with an air cooled generator.

Supervisory control instruments are provided in addition to the usual pressure gages and thermometers. An electro-magnetic vibrometer indicates and records vibration of the machine at any point where mounted and gives permanent records as well as instantaneous readings of the vibration in three directions. This information is used for determining straightness of the rotor in starting the unit and while bringing it up to speed. An expansion meter indicates and records the expansion of the cylinder due to temperature, giving accurate information during starting periods as to whether or not cylinder parts are expanding normally, and affords warning of any unusual operating condition.

Steam for the new high pressure unit is supplied by two Combustion Engineering 500,000 lb. per hr., 1400 lb., 900 deg. F. boilers with slag tap, fin tube furnaces, Elesco superheaters and economizers and Ljungstrum air preheaters arranged as shown by Fig. 5. Superheat control is obtained by use of automatic gas by-passes which will maintain the superheat constant at any desired point between 850 and 900 deg. F. over a load range from 375,000 to 500,000 lb. per hr. Each boiler is fired by two Raymond bowl mills through eight tangential burners. The powdered coal is ignited by gas burners, supplied from the city gas mains, and with sufficient capacity to bring the boiler on the line without the use of powdered coal. Each boiler is equipped with two Sturtevant duplex vane control forced and induced draft fans driven by constant speed motors.

Because this plant is adjacent to the high class Grand Central zone, every effort has been made to insure the elimination of nuisance from the stack discharge. Boilers are equipped with three section Cottrell precipitators, having a guaranteed efficiency of 95 per cent, from which gases are discharged from the stack 450 ft. above the street level, a point higher than any building with 1000 ft. of the plant.

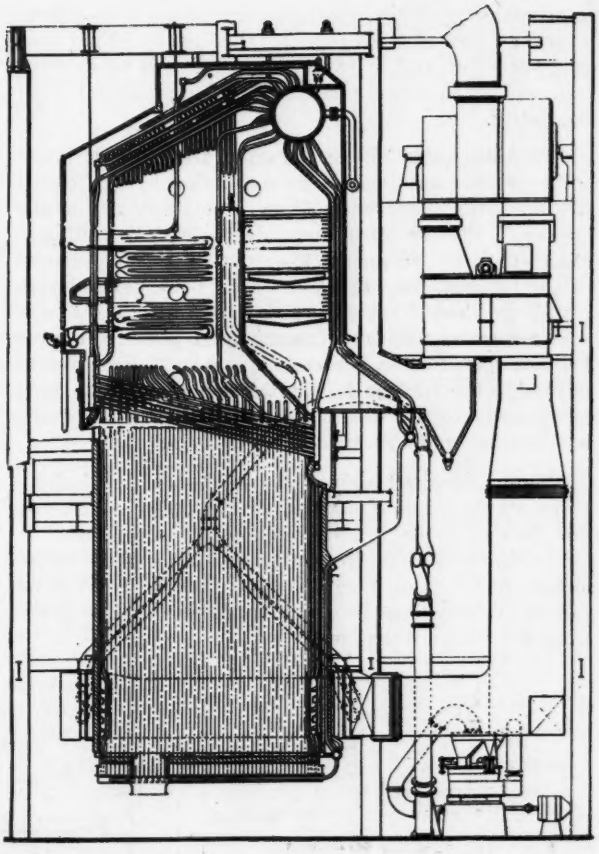


Fig. 5. The 500,000 lb. per hr. 1400 lb. 900 deg. F. boilers will each be fired by two Mills and eight burners. The furnace is water cooled and has a continuous slag tap bottom

Piping

High pressure steam piping is laid out to have a separate 12 in. lead from each of the two boilers connected to one high pressure turbine. These two leads are joined at the turbine where a spherical mixing chamber is installed. Condensate from these lines is collected by a drip system which discharges to the boiler blowdown header. A thermometer well is provided at each draining point so that the operator may note by the temperature, when superheated steam is being discharged and can then close the drain valve. One non-return and one motor operated gate valve are installed in each boiler lead. Piping material installed for the high pressure steam service is seamless carbon molybdenum with solid forged fittings. The gate valves are carbon molybdenum with nitralloy faced seats.

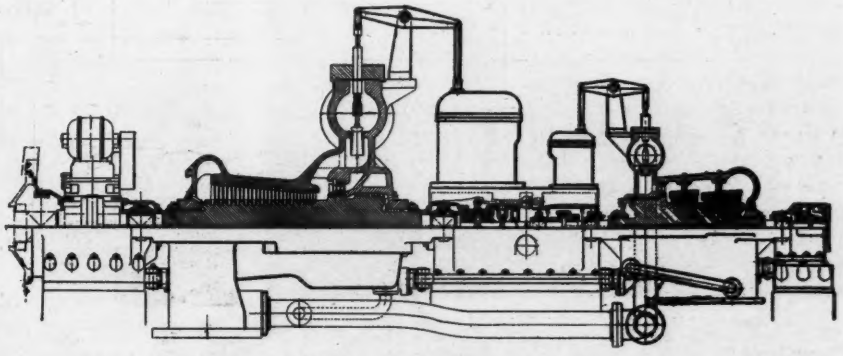


Fig. 4. Operating at 1200 lb., 900 deg. F. the main turbine is rated at 46,700 kw. and exhausts at 200 lb. The feedheating turbine at the right of the main unit is rated at 3300 kw. It operates between 200 lb., 502 deg. F. and 5 lb. back pressure and bleeds at 60 lb.

Expansion of the high pressure steam lines, about 1 in. for every 10 ft. of pipe, is taken up by 50 per cent cold springing and by expansion loops. All bends were laid out to as large a radius as was consistent with flexibility.

Feed discharge piping of carbon steel was designed wherever possible with large radius bends and forged fittings. All valves 8 in. diam. and above are motor operated. The 200 lb. piping system connects the main exhaust of the turbine to the existing 200 lb. headers of the two stations. It was necessary for flexibility to install in these lines several creased bends and also a considerable amount of corrugated pipe. A double bellows type Foster Wheeler expansion joint directly adjoining the turbine is installed to allow for turbine movements in all directions without subjecting the machine to undue strains.

Motor operated valves are each controlled from three stations, one local, one on the boiler board and one for emergency closing only, on a board located in the turbine room engineer's office. The high pressure steam, boiler feed discharge and 200 lb. per sq. in. piping are wherever practical supported on Genspring Constant Support hangers.

High pressure steam, boiler feed discharge and 200 lb. pipe lines are all welded. The valves are furnished with welding necks of sufficient lengths to allow for the application of the stress relieving collar after welding. Welded joints in the high pressure steam lines were preheated, before welding, to between 400 and 600 deg. F. In the boiler feed discharge only joints adjacent to valves were preheated to a minimum of 400 deg. F. The 200 lb. joints were not preheated. After welding and stress relieving, at a maximum temperature of 1150 deg. F. the joints, both field and shop welds, were X-rayed. In addition, all lines were hydrostatically tested after erection.

Due to code requirements and to insure that the 200 lb. piping system would not be subjected to a higher pressure, a battery of seven 6 by 8 in. safety valves are installed on a stub end line connected to the 200 lb. exhaust from the turbine. These valves are designed to discharge through flexible corrugated pipe into one of the station's free exhaust tunnels.

High pressure exhaust from the turbine is connected to the 200 lb. header of the station and will be operated in parallel with a number of the existing low pressure boilers. In order to insure that the high pressure boilers are fed with condensate only, as

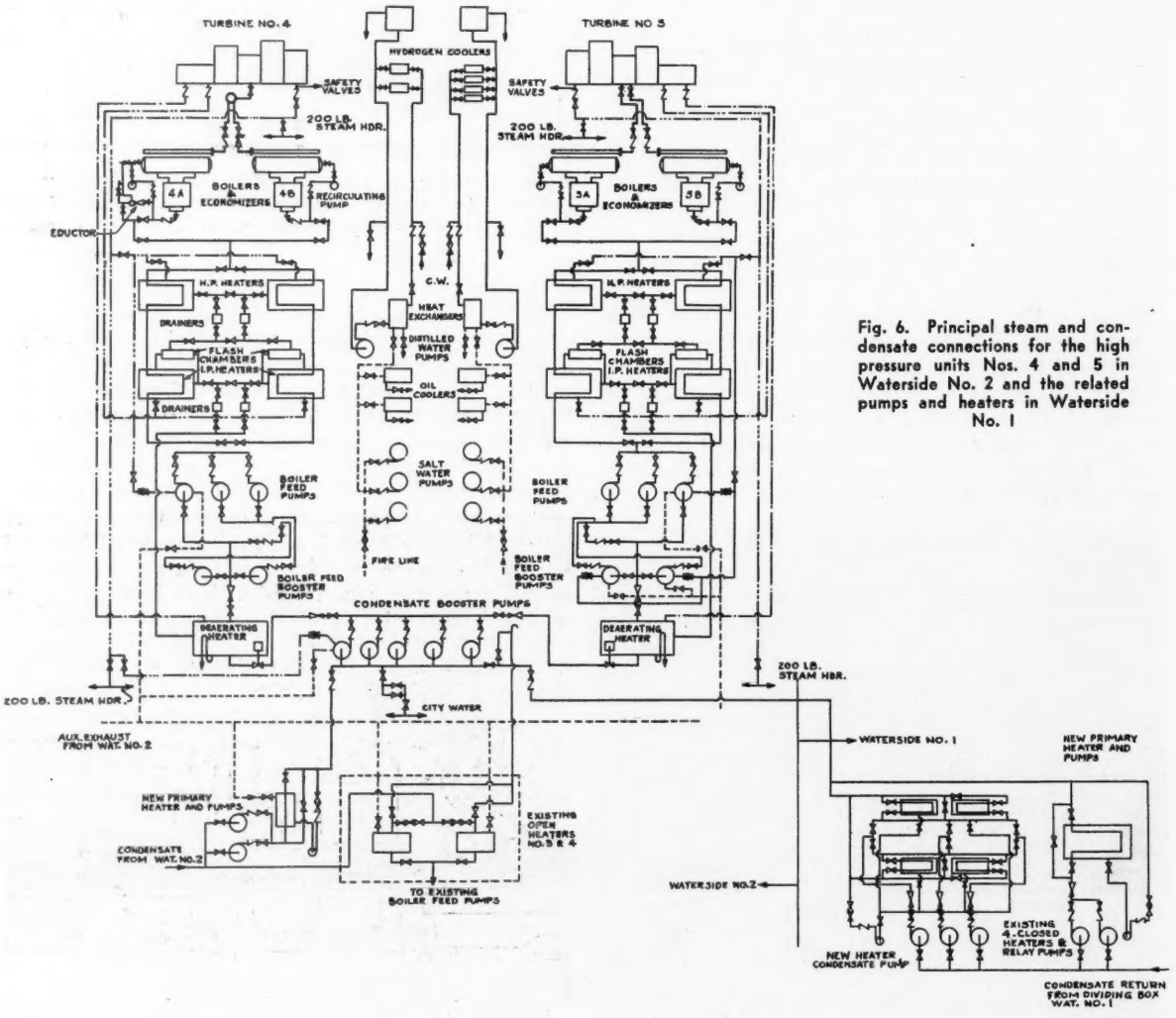


Fig. 6. Principal steam and condensate connections for the high pressure units Nos. 4 and 5 in Waterside No. 2 and the related pumps and heaters in Waterside No. 1

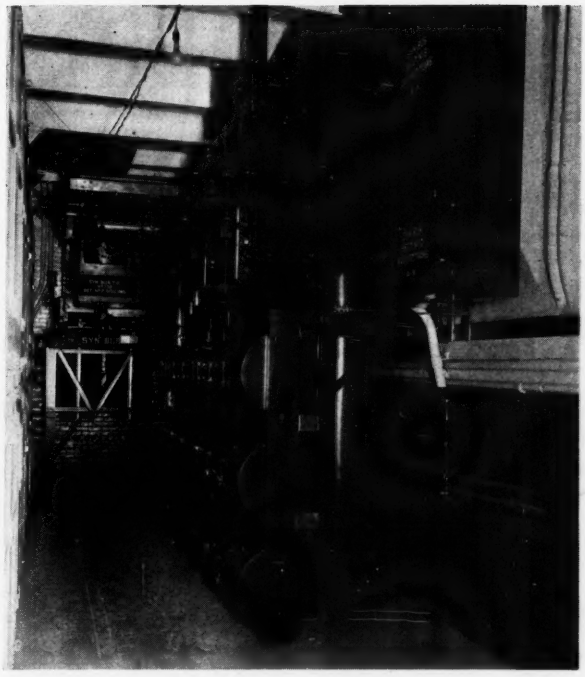


Fig. 7. Entirely metal covered switching equipment and bus structure construction is particularly well adapted to the narrow electrical gallery. This is the synchronizing bus and disconnect switches

long as a sufficient supply is available, the piping has been so arranged that the condensate flows first to the high pressure feed lines and if the quantity is in excess of the requirements for this purpose it spills over a loop to the low pressure boiler feed system. Provision is made for automatically supplying city water make-up to the deaerating heater in the event of a deficiency in the supply of condensate.

From the heat balance diagram shown in Fig. 1 it will be seen that the condensate from the low pressure units in Waterside No. 1 is passed through existing closed heaters in this station where it is heated to about 150 deg. F. by the exhaust steam from the turbine auxiliary. From this point it is pumped across the street to the deaerating heater located in the boiler room adjacent to the new high pressure boilers. Steam for this deaerating heater is supplied from the exhaust of the feed-heating turbine at a pressure slightly above atmosphere. From this point it is pumped at boiler feed pressure through an intermediate heater, taking bleed steam from the feed-heating turbine at about 75 lb. abs., thence through a final heater supplied by 200 lb. steam from the crossover connection. Pressure of steam to the deaerator will be maintained constant by a back-pressure governor on the feed-heating turbine, the pressure at the intermediate heater varying with the load on this unit.

Feedwater Supply

Three Worthington barrel type main boiler feed pumps are provided, two of which are driven by constant speed a.c. motors and one by a Moore steam turbine, operated from the 200 lb. steam header. Under normal conditions the two motor driven boiler feed pumps will be in operation, taking their suction from the discharge of an Elliott 1,200,000 lb. per hr. deaerating heater. In order to provide for the additional feed pressure requirements when one of the two parallel sets of high pressure heaters is out of commission and to meet any other emergency conditions, two motor driven booster pumps are so arranged that they can be operated in parallel with the two motor driven boiler feed pumps supplying an additional 200 lb. of feed pressure. These booster pumps are provided for push-button start from the boiler control board, their discharge pressure being regulated by a motor-driven throttle valve controlled from the same point. The turbine driven boiler feed pump is provided with an automatic starting valve which will bring the pump up to full speed on a predetermined drop in pressure on the boiler feed line.

All of the auxiliaries, except the emergency boiler feed pump, are driven by constant speed motors supplied by transformers from the main station bus. The auxiliary feeds are so arranged that there is one automatic switch in the circuit supplying all of the auxiliaries for each of the boilers so that in case of a short circuit on any of the electrical equipment all of the auxiliaries on the boiler involved will be similarly interrupted.

Switching equipment and bus structure is entirely metal covered, a relatively new development particularly adapted to the confined space of the Waterside switch gallery. The entire gallery is only 13 ft. wide and the compactness of the bus arrangement is illustrated in Fig. 8. Each new generator will be connected to a stub bus supplying eight outgoing feeders. Each stub bus will have a secondary source of supply, either a low pressure turbine, frequency changer or interstation tie.

The design and construction of this installation has been accomplished with few difficulties and in the average length of time, and it is expected that operating records will indicate a full justification of the project.

Fig. 8. Enclosed main bus and disconnect switches represents the latest practice, a radical departure from designs of but a few years ago

MODERN

This is the first of a new series of articles discussing the basic elements and the engineering aspects of modern steam turbines. Perhaps you feel that you know enough about turbines to suit your needs but we suggest that you read this first installment at least; probably you will find in it certain facts which had not come to you before and which may prove of interest. Mr. Newman's treatment of the subject is decidedly refreshing and carries with it not only the weight of his own experience with turbines but also that of the organization with which he is associated.

By L. E. NEWMAN

Turbine Division
General Electric Co., Lynn, Mass.

DID YOU KNOW that modern turbines may admit steam at a temperature hot enough to set fire to a piece of wood and exhaust it at a temperature too cool for a comfortable bath? And that this drop in temperature takes place in less than one-half second? During this short interval of time steam has entered the turbine, given up its energy to the rotating wheels, and increased its volume possibly a thousand times before leaving the turbine exhaust. Yet this incredibly swift conversion of heat energy in the steam into mechanical energy in the shaft, taking less than one-half second, is painstakingly slow compared to the transition from mechanical to electrical energy in the generator; that, from any practical standpoint is instantaneous. Thus, when you switch on your electric lights you are enabled to see in the dark by a flame then burning under a boiler at some distant power plant.

Isn't it worth learning something about these turbines which make such things possible?

Steam turbines furnish the bulk of electric power used today, but they do not furnish this power directly. Steam does not enter one end of a turbine and electricity emerge from the other, but a generator driven by the turbine generates the electricity. The turbine is merely a "steam motor" driven by steam in much the same way that electricity drives the electric motor. However, turbines are supplied with energy in the form of heat energy in the steam and convert this into useful mechanical energy. Because of this they are called "prime-movers". Any engine which, in the sequence of energy transformations in the generation and use of power, first converts energy from one form into mechanical energy is called a prime-mover.

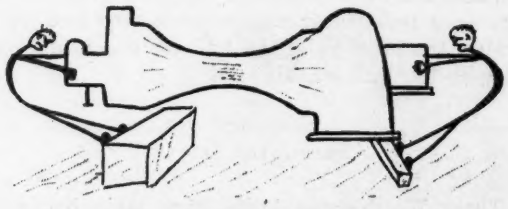
Of all prime-movers the turbine is the most flexible. No other prime-mover could be built any more tiny than the smallest turbine which could be built, and no other prime-mover has been built as powerful as the largest turbine generator set. Basically the turbine principle (whether liquid, gas, or vapor functions as the driving medium) is one whereby energy is converted *directly* into *rotating* motion. Many other forms of prime-movers convert energy from one form into reciprocating motion, and this in turn into rotating motion. It is this intermediate step of converting the energy first into reciprocating motion that inherently limits the size of such machines.

The immediate conversion of one form of energy into rotating motion, without intermediate steps, is the primary advantage of a turbine. By rotating steadily, all parts of the rotor move constantly and continuously in the same direction without rapid reversals of direction, which, in the case of large masses, introduce great stresses. Moreover, power is the product of torque and speed, and with direct rotation high speeds can be used, which greatly decreases the size or the turbine. If a given power were needed, and this power could be used at a very high speed, without gearing, no other prime-mover could be made so small and so light, yet still retain the high structural strength of a turbine.

Two simple "tin can" models will illustrate the basic principles underlying the two fundamental forms of steam turbines. The first of these is the *impulse* turbine, (Fig. I), deriving its name from the fact that the rotating member is pushed around by the force of steam impinging on paddles, more commonly called "buckets" or "blades".

The second of these is the *reaction* turbine (Fig. 2) so-called because it is the "reactive kick" from steam in the rotating element which causes it to rotate.

Commercial turbines do not look like these elemental models, but operate on the same basic principles. For the present, if we understand that in an impulse turbine



Of all prime movers the turbine is the most flexible

TURBINES

the rotor is maintained in motion by steam striking rotating buckets, or blades; and that in the reaction turbine the rotating member derives its rotational force from the steam leaving the blades; and that all commercial turbines make use of one or the other of these principles, or a combination of them; we have sufficient foundation to proceed with a further examination of the turbine.

Note the few parts of a turbine. Basically all that is needed is an orifice, or nozzle, through which steam issues, and buckets mounted on the rim of the wheel. Fundamentally, nothing else is needed for a workable power-producing turbine. A casing is added to confine the steam, and valves are added to control the admission of steam to the nozzles. These valves are in turn controlled by a governor, and more stages may be added to aid in efficiently utilizing the energy in the steam. For various reasons other modifications may be made, but basically, a turbine consists of only two elements; first, the nozzles, and second, the rotor.

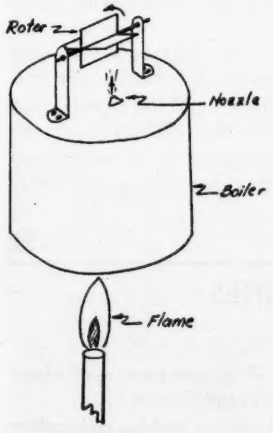


Fig. 1. Elementary Impulse Turbine

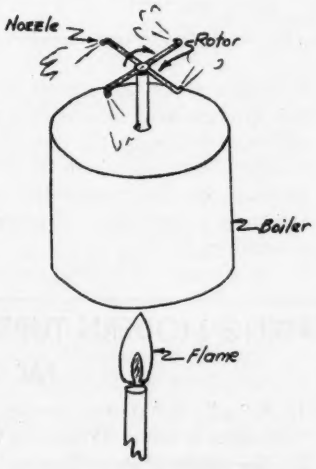


Fig. 2. Elementary Reaction Turbine

Multi-staging does not change the principle of operation. The only reason for adding stages is to increase the efficiency of the turbine at any given speed, and as any stage has its best efficiency under certain conditions of speed and pressures, it is usually necessary to multi-stage the turbine to obtain the high efficiencies required today. Why a single turbine wheel has its best efficiency under one set of operating conditions may be understood from a study of the elemental turbine. (Fig. 1)

If it is assumed that this simple turbine has a fixed pressure in its boiler then it follows that a constant flow of steam will issue from its nozzle and this steam will be traveling at a constant velocity. When the paddle wheel (or turbine rotor) is held stationary the steam issuing from the nozzle strikes it with its full force and exerts its greatest possible turning effort. In any turbine the maximum torque occurs at standstill when the steam issuing from the nozzles strikes stationary buckets. But under this condition the rotor is not moving and hence no work can be done. It is the condition of maximum torque, zero speed, and zero work.

At the other extreme consider the case where the speed of the rotor is the same as the speed of the steam. With equal bucket and steam speeds, the steam

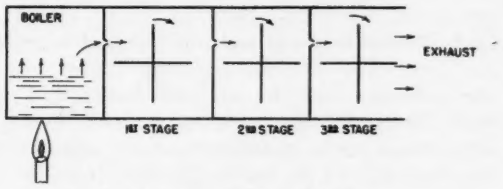


Fig. 3. Multistage Impulse Turbine

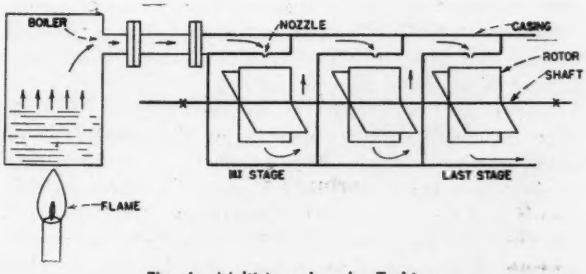


Fig. 4. Multistage Impulse Turbine

has no velocity relative to the bucket and can exert no turning effort. This condition, then, is one of maximum speed, zero torque, and zero work.

In between these two extremes work can be done as there will always be force exerted by the steam and the rotor will always be in motion. But as the speed is increased from zero to the maximum there will be a point where the product of turning effort and speed will result in the greatest work being done. This will be the point of best efficiency for that stage.

In actual practice turbines are seldom applied to loads where the turbine can seek its most efficient speed. Usually the turbine speed must be held constant and this is done by a speed governor, which adjusts the steam flow to the load to be carried. Structural limitations prevent turbines being built for usual commercial speeds with a single wheel large enough and efficient enough to use the energy available from most conditions of steam pressures, so another turbine is placed in series somewhat in the fashion shown by Fig. 3.

This is a true multistage turbine. Steam is generated in the boiler at a high pressure, issues from the first stage nozzle and gives up a portion of its energy to the first stage wheel. The steam in the first stage shell is at a pressure less than boiler pressure, and this pressure will be reduced in each succeeding stage until finally the steam is exhausted. Note, however, that this turbine would be neither practical to build

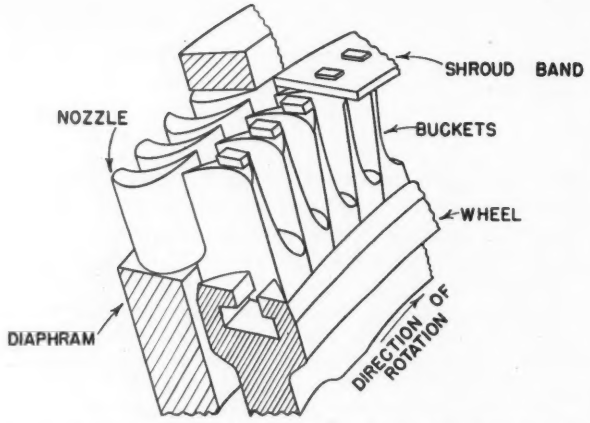


Fig. 5. Detailed drawing of nozzle and buckets of an impulse turbine

nor operate, with its integral boiler and separate shaft for each stage. Figure 4 shows how the turbine would look, redesigned, with all wheels on a single shaft, and the boiler divorced from the turbine.

The final step in making the elemental turbine into a commercial turbine requires simply multiple nozzles of proper design, and changing the shape of the inefficient "paddles" to efficient buckets having curved entrances and exits. The resultant steam path may appear as shown in Figs. 5 and 6.

Compare the simple two-element turbine, Fig. 1, with its single moving part to an elemental type of steam engine (Fig. 7). For such a reciprocating engine there must be cylinder, piston, connecting rod, crank, and flywheel; five basic elements, four of which are moving. Such an engine, or other familiar prime-movers employing a reciprocating principle, develop power that is pulsating. The flow of power is not uniform through even a single power stroke of the piston, but increases and diminishes in force.

These pulsations are inherent in the reciprocating type of engine, and, in former years, were apparent in every revolution of the model "T" engine. Every explosion in the cylinders could be felt as a distinct vibration, and these vibrations could only be effectually minimized by adding cylinders or a flywheel. More cylinders increase the number of impulses received by the crankshaft in each revolution, and heavy

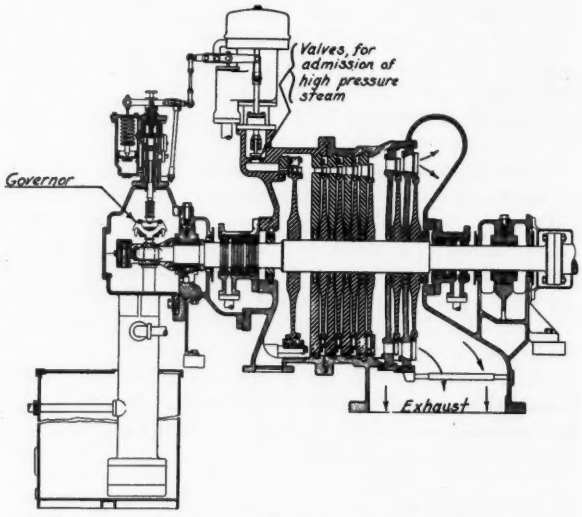


Fig. 6. Section through a condensing turbine of the impulse type

flywheels store the energy of each impulse spreading this energy over an entire revolution. Additional cylinders complicate the mechanism, and flywheels add weight, both of which increase the difficulty of the problem of the automotive designer in approaching the same smooth flow of power that could be had from a turbine.

In a simple turbine, such as shown in Fig. 1, the

FACTS AND FANCIES REGARDING MODERN TURBINES

FANCIES	FACTS
1. A turbine has practically no starting torque.	1. Actually the starting torque of the average multi-stage turbine is about TWICE its full-load torque.
2. The output of a turbine varies directly with its speed.	2. The weight of steam flowing through a turbine determines its output. The speed can be varied over a wide range without appreciably affecting the output of a multi-stage turbine.
3. Regardless of other factors, the lower the steam rate the higher the efficiency.	3. At different steam conditions, one turbine having a 50 lb. steam rate might be twice as efficient as another turbine having a 15 lb. steam rate.
4. For any given rating a turbine has a definite size.	4. The initial and final pressure are as important as the rating in determining physical size of a turbine.
5. Turbines are only suitable for constant speed service.	5. Turbines are used for many applications requiring wide ranges of speed.
6. A condensing turbine, 100% efficient, would convert all of the energy in the steam into power.	6. Roughly ⅔ of the heat energy put into the steam in the boiler is lost in the condenser.
7. A little bit of moisture in the steam supplied a turbine doesn't hurt the economy very much.	7. In addition to increasing the wear, each 1% of moisture in the steam means about 2% poorer steam rate.
8. If the steam pipes are well insulated, you don't lose anything by getting the steam for the 10 lb. process line by reducing valve from the 200 lb. boiler header.	8. Wherever a reducing valve can be replaced by a turbine, power can be had at the lowest possible fuel cost.
9. Unless steam is at a fairly high pressure, you can't get much power from it.	9. There is MORE energy available for power when steam at atmospheric pressure is expanded to a high vacuum, than when steam at 200 lb. square inch pressure is expanded to atmospheric pressure.

shaft would not rotate exactly smoothly but would receive four power impulses in each revolution. Offhand this would seem "jerky", but, with its four paddles, it is receiving the same number of impulses in a revolution as a modern eight cylinder automobile! We think of the "straight-eight" as giving one continuous smooth flow of power to the wheels, but consider the turbine in comparison. Simple commercial turbines, with over a hundred buckets on each of several stages, and these buckets fed by steam from multiple nozzles, are the equivalent of an automobile engine with more than one-hundred thousand cylinders! Flow of power from such a turbine is so smooth that a flywheel is not needed to stabilize it.

How little "fly-wheel effect" there is in a steam turbine may be illustrated by a typical modern steam turbine rated, say 5000 k.w. If full load were suddenly dumped from its generator and the turbine had no operating nor safety governor, the turbine would accelerate at a rate fast enough to reach double speed

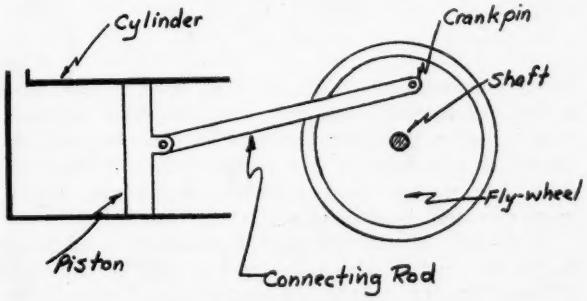


Fig. 7. Elemental Steam Engine

in less than six seconds! This would be alarming if it were not for the fact that modern governors are so rapid in their action that even under such severe conditions the speed would rise only a few per cent.

Omission of the fly-wheel, and, the use of high rotative speeds, make it possible to build powerful turbines occupying relatively small spaces with no sacrifice in factors of safety. Examples of the relatively small size of turbines compared to other prime-movers is strikingly illustrated by a 110,000 k.w. steeple-compound turbine. The floor space occupied by this turbine with its generator would be insufficient to park a dozen motor cars whose aggregate horse-power would not total a hundredth the power of the turbine.

For the higher ratings this reduction in size coupled with simplicity of design reduces the cost relative to the larger (in physical size) and more complicated prime-movers, and, with the freedom from vibration, lighter foundations are used. Because space is usually at a premium in crowded metropolitan areas, industrial plants, or aboard ship, this factor of small size alone is sometimes important enough to determine the choice of a turbine versus some other prime-mover.

It might seem from what has been said that the turbine could have no logical competitor. This is true insofar as the large turbines are concerned, but far from the fact when considering the small turbines. In the present stage of development of small turbines there are many applications where a turbine would be far from the best source of power. For example it would be irksome to have to carry a boiler plant with you in your car when the internal combustion engine combines boiler plant and prime-mover within a single engine. And, again, for slow speed applications the turbine's small size is offset to a certain extent by the reduction gear which may not be necessary with a slow speed prime-mover. Nevertheless, if the automobile engine could be replaced with a "gas turbine", and if the slow speed prime-mover could be replaced with a slow speed turbine, maintenance would be less and operation would be smooth beyond anything yet developed for these and kindred applications.

Assuming an automobile with direct turbine drive could be purchased, and driven as far each year as the average car travels, its owner within his lifetime would never have to make a major repair or replacement! The average modern turbine, compared to an automobile running at thirty miles an hour, would cover a distance of 250,000 miles the first year and even then would not be ready for its first inspection. Given reasonable care and minor replacements many turbines have operating records, which, again on the basis of the automobile, amount to several million miles of travel with never an outage caused by failure of any part.

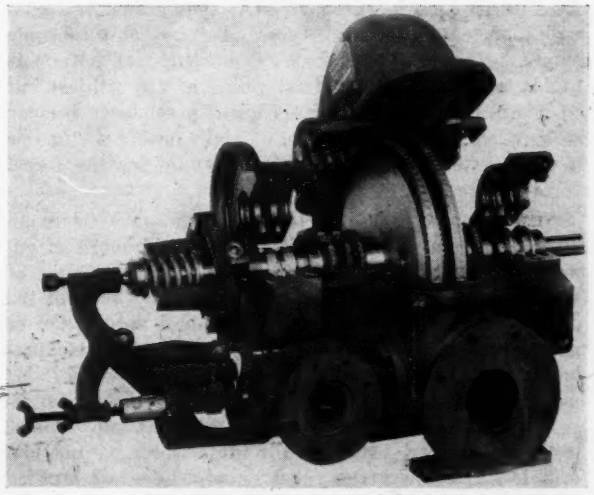


Fig. 8. A Small steam turbine with the top half of the casing raised to show the wheels and blading

So much for the fundamentals necessary to an understanding of why turbines today are paramount in the field of prime-movers. A generation ago it was the mighty Corliss engines impressively delivering power. Their places were taken by silent steam turbines; smooth in operation, not nearly so impressive to see, but far more powerful. Of present day prime-movers the turbine was the first invented, and last to be perfected, but with its continued development will probably find its field of usefulness increasingly extended.

A NEW DEVELOPMENT in X-ray technique permits the taking of X-ray photographs around obstructions which may exist in front or behind the object photographed. This development due to Jean Kieffer of the Connecticut State Tuberculosis Hospital makes use of an X-ray tube and photographic plate moving in opposite directions during exposure.

PART XIX

In order to present a more complete picture of the subject of electron tubes as a whole we present here, a brief review or recapitulation of the important parts covered in the first eighteen chapters of this series. Several additional principles are discussed, one of which is the so-called Dynatron action resulting from secondary emissions in certain types of circuits

Electron Tubes— Principles and Applications

By A. W. KRAMER

IN THE preceding eighteen chapters of this treatise consideration has been given to the details and principles of many different types of tubes and to some extent to their applications. Knowledge of details is highly essential to an understanding of any subject but in a study such as this it is quite possible to become so absorbed in details as to lose sight of the picture as a whole—we get so close that we cannot see the forest for the trees.

This, however, is just the thing we want to avoid. There are many books available and still more magazine articles and scientific papers, to say nothing of manufacturers' bulletins and catalogs which present the detailed theory, design, construction and application of all types and sizes of electron tubes far more comprehensively than we could possibly hope to do here. This material, however, is written largely for those who already have a good basic knowledge of the subject and quite often is too advanced for those who have not had occasion to use electron tubes or who have not studied their basic principles. Details of applications will be considered in later articles, but, thus far, our purpose has been to present a picture of the subject of electronics as a whole, to impart its philosophy, and to correlate its various branches. The electron tube, as we have endeavored to point out, represents something far more than merely a new device or tool for the electrical engineer, it represents a new point of view, a new approach to methods and principles which only a few years ago were thought of as forever closed.

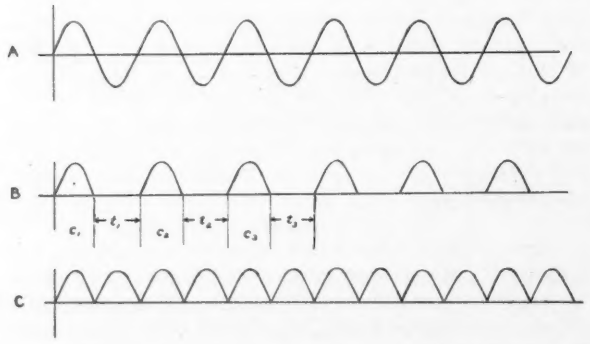


Fig. 1. Simple rectification does not result in a direct current as the term is ordinarily understood. It results in a pulsating current which although uni-directional is unsuitable for many purposes

Consider for example such a commonly used thing as the a.c. radio receiver. Previous to 1920 the idea of transforming alternating current into pure direct current by means of purely stationary equipment was almost unthinkable. Then came the radio receiver with its vacuum tubes and the need for pure direct current in their plate circuits. At first this necessary direct current was derived from dry batteries—"B" batteries —but these gave maintenance troubles and so an effort was made to obtain a source of direct current from the alternating current mains. The first attempts at this were feeble, due to the lack of suitable rectifier tubes but once the principle involved was understood development was rapid. Some of the first so-called B-battery eliminators used rectifiers of the electrolytic type but these were soon replaced by thermionic rectifiers.

The problem involved here was more than mere rectification. Simple rectification of an alternating current such as that represented by A in Fig. 1 produces not a smooth unvarying current such as that required by a radio receiver but a pulsating current such as that represented by B in Fig. 1, or even where full wave rectification is used, a pulsating current such as that represented by the wave C. The production of a smooth unvarying current from a rectified output such as that represented by B or C implies the concept of *storage*—storage of electrical energy. It is obvious that at the times, t_1, t_2, t_3, etc. in wave B there is no source of e.m.f. in the circuit, and if a current is to exist at these times, it must be derived in some way from pulsations C_1, C_2, C_3, etc. In other words, some of the energy represented by the pulsations C_1, C_2, C_3, etc., must be shunted into some sort of a storage reservoir and held there until the times t_1, t_2, t_3, etc., and then released. Ordinarily, the concept of storage of electricity is unthinkable; in the power industry it is frequently pointed

out that electricity is the *one* thing that cannot be stored—it must be utilized the very instant it is generated and that is why public utility companies have to consider such things as load factor and diversity factor and many other intangible elements so confusing to the general public. For such short intervals of time as represented by the intervals between successive half waves of ordinary alternating current, i. e., 1/120 sec., it is entirely possible to store electricity in condensers, or capacitors as they are called nowadays. Condensers alone, however, are not enough. Such condensers obviously must be connected permanently into the circuit in order that the energy stored in them during the times C_1, C_2, C_3, etc., may be released at the times t_1 t_2 t_3, etc., some sort of a delay arrangement must be introduced. This delay is provided by inductance coils or "chokes." The effect of inductance, it is well known, is just exactly opposite to that of capacity in an electrical circuit.[1] One (capacity) causes the current to lead the impressed voltage whereas the other (inductance) causes it to lag behind the impressed voltage. By suitably combining inductances and capacities in a network a "filter" circuit is set up which brings about the result desired; i.e., during the active portion of the cycle (times C_1, C_2, C_3, etc.), a portion of the energy is stored up in the condensers and the inductance and then released at the times t_1 t_2 t_3, etc. Such a filter circuit is shown in Fig. 2.

This is a comparatively simple filter—others are more complicated but in general the theory of their operation is the same. Both the inductance and the condensers possess the ability to store electrical energy, the former in the form of the electromagnetic field, the latter in the dielectric field. While the amplitude of the rectified a.c. wave is increasing, energy is being stored both in the inductance and in the condensers, after the peak has been reached and the amplitude of the rectified

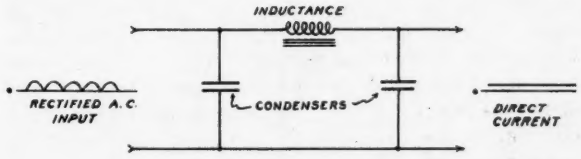


Fig. 2. By means of a "filter" circuit such as this the pulsations of a current such as represented in Fig. 1 are ironed out and a pure direct current results

wave begins to decrease, the stored-up energy is released and this fills in the valleys between the rectified humps. The filter, it will be evident, is the electrical counterpart of the flywheel in mechanics.

Our purpose in introducing this discussion of filter circuits here is not so much to explain the action of these circuits as it is to show how the electron tube has extended the usefulness of already known principles and properties of circuits. Before the advent of electronics alternating current and direct current were two distinct and entirely separate entities, interconvertible only through means of rotating equipment, motor generators and rotary converters. Today, alternating and direct current circuits are combined and interconnected in all sorts of ways; in some instances as in the automobile radio receiver, direct current from the battery is transformed into alternating current through the agency of the vibrator and this alternating current at high voltage is again converted into direct current. In other words, limitations which once were insurmountable now no longer exist.

A similar condition exists with respect to change of frequency. Frequency at one time, except as circuit operation was affected by usually objectionable harmonics, was something that was unalterably determined by the generator. Frequency change could be obtained only by means of rotating frequency changers. Today, because of the electron tube, frequencies can be changed or varied over wide ranges by purely static equipment. This, naturally, provides entirely new possibilities in the use of certain types of equipment. A synchronous motor for example can be started and brought up to any speed and operated at that speed merely by supplying the proper frequency from electron tube equipment.

These developments, even though they have not reached appreciable commercial proportions, nevertheless require a new point of view of the electrical art. Because of the science of electronics and the electron tube the electrical art becomes a much more homogeneous whole.

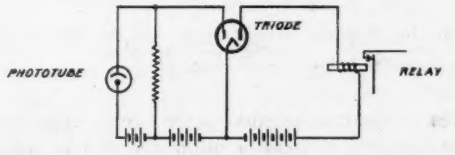


Fig. 3. Showing the use of a triode amplifier in adapting the phototube to the operation of a low resistance power relay

In the preceding chapters we have discussed in some detail various types of tubes and their characteristics. Let us review them briefly. To begin with, there was the two electrode tube which gave the fundamental property of rectification. Next came the triode with its valuable property of amplification. The effect of introducing inert gases into both of these tubes was considered at length and was shown to alter the character of the triode completely.

The result of amplification with certain types of tubes was next shown to be oscillation, that is, the generation of alternating current of any frequency. The principle of oscillation, however, valuable as it might be in certain respects, was shown to introduce limitations in the use of triodes as amplifiers, so schemes for neutralizing circuits were developed and these were described. The neutralized amplifier circuit, however, was an expedient developed to overcome certain difficulties—a makeshift, so to speak, which itself introduced limitations, which were objectionable. So a new type of tube was developed, the four electrode or screen grid tube which nullified the interelectrode capacity effect in tubes and therefore made neutralization unnecessary.

The four electrode tube, however, was characterized by what is known as secondary emission and so, finally to prevent this, still another electrode, the suppressor grid, was introduced. Thus, the pentode came into existence.

[1]The fundamental properties of inductance and capacity and their effects in electrical circuits are fully discussed by the author in "Electricity—What It Is and How It Acts," Volume I and also in "This Thing Called Power Factor" published by Technical Publishing Co.

These, constitute the principle ordinary tubes but as was shown there were others, the X-ray tube and the cathode ray oscillograph, which utilized the principles involved in these others but because of their specific functions had to be considered separately. Finally we discussed the photo-electric tube and the principles involved in photoelectric emission.

Thus, it is evident that these tubes, though each possesses certain special functions, are related either by virtue of the principles involved or through evolution. The pentode is related to the diode through all the intermediate members of the family and though its special function is that of amplification, it is fundamentally a rectifier.

The photo-electric tube, obviously, is in a class of its own since it possesses a specialized function but here

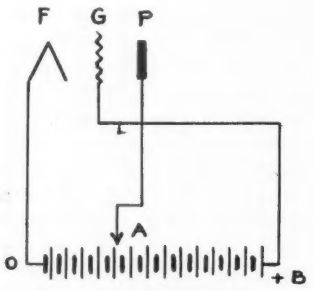


Fig. 4. The Dynatron circuit. Note that the grid is at a higher potential than the plate

again we find a relation with other tubes such that it is virtually impossible to think of one without the other. The most sensitive photoelectric tubes (but not photovoltaic devices) would be almost useless were it not for the thermionic amplifier. The output of the ordinary phototube is so small that only the most sensitive and high resistance relays can be controlled by it, without some type of intermediate amplifier. That is why in all applications where phototubes are used, one or more thermionic amplifier tubes will be found in the circuit.

Consider a simple circuit, such as that shown in Fig. 3, where a phototube is used to operate a simple magnetic relay through a triode amplifier. The grid-cathode path of the triode is of a high resistance—many megohms if the grid is negative. The plate circuit on the other hand has a very low resistance, of the order of a few thousand ohms. These features admirably adapt the circuit for connecting a phototube to a power relay. The phototube has a resistance of many megohms whereas the ordinary power relay has a low resistance—from a few ohms to a few thousand. Although the output of a phototube may be as high as 30 volts, its resistance is of such a high order that it would be short circuited by the average power relay connected across it. In other words, the phototube cannot deliver sufficient power to operate a low resistance relay directly.

If, however, an amplifier circuit is introduced between the phototube and the relay as shown in the diagram, a different condition prevails. Here, if the phototube changes the grid voltage of the tube, the plate current of the tube will operate the relay. The tube acts as a transformer in which both the current and the voltage are stepped up. The power amplification obtained in this way is easily of the order of 2000 to 3000 times.

This, it will be obvious, is only a typical example of countless other applications of the thermionic amplifier, but it serves to show how the amplifier gave new life to an effect which had been known for many years. The photoelectric effect was discovered many years ago but it was too feeble to be of any practical use until the thermionic amplifier came into existence.

The value of the thermionic amplifier is almost beyond conception. Already it has revolutionized the whole field of communication. Where once the voice currents in telephony were infinitely tiny affairs, capable of being reproduced only by the most sensitive of electromagnetic systems, today, because of the amplifying powers of the electron tube they are given magnitudes of amperes and even hundreds of amperes. A baby's cry can be made to shake a cathedral to its very foundations. In the same way tiny variations in the output voltage of a generator can be made to operate powerful equipment used to stabilize that voltage. The possibilities are endless. In fact, in many communication systems the amplification is so great that the granular structure of electricity becomes noticeable and in some instances becomes a limiting factor in the operation of these circuits. This is the effect which refers to the noise created by the passage of individual electrons flowing in the circuit. Astonishing as this may seem, it is a factor of decided importance in the design of sensitive circuits.

The matter of oscillation generation was described briefly in Parts X and XI[2]. The full importance of this process is more fully appreciated by the communication engineer than by power men at the present time, since electron tube oscillators form the basis of nearly all communication circuits. No mention was made, however, of the methods by which electron tubes modulate electrical oscillations to suit them to whatever purpose we desire. In a typical radio broadcast transmitter

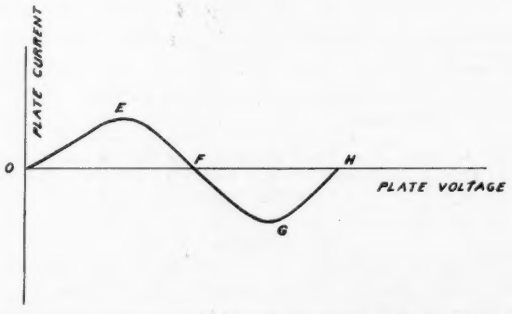


Fig. 5. The negative resistance characteristic of the Dynatron

voice currents created by one of several possible types of microphones (some of which are entirely electronic in their action) are amplified by a series of ordinary amplifying tubes (the speech amplifiers) and the output of these is impressed upon modulator tubes the function of which is to mold the high frequency output of the oscillator tubes in such a way that these oscillations will vary in amplitude exactly in accordance with the variations of the voice currents leaving the microphone.

[2]November and December 1936 issues.

The meat packing industry is noted for its effective use of its otherwise waste products and it is said that everything is used except the squeal of the pig. But, as was pointed out in an earlier chapter, in the electron tube even the squeal is used. For the squeals issuing from De Forest's early regenerative receivers were nothing but a manifestation of oscillation generation and this has proved of inestimable importance.

Another example may be cited showing the use of an effect which in some instances is undesirable. In the discussion in Chapter XIV, it was shown that secondary emission limited the action of the screen grid tube and so the pentode was developed to overcome this limitation. In some types of tubes, however, this principle of secondary emission is actually put to good use. One of these is the Dynatron, a special arrangement of the triode first introduced by A. W. Hull. In the Dynatron circuit, the triode is connected so that the grid is at a higher potential than the plate as shown in Fig. 4. Under such conditions it is evident that any secondary electrons produced at the plate will be drawn to the grid by virtue of the higher positive potential existing there.

If, with a circuit of this kind the plate potential is gradually increased from zero by moving the contact A to the right, the plate current will increase at first, then as the plate voltages rise still further, secondary electrons will be produced at the plate and as these are drawn to the grid, they constitute a reverse plate current. At a point of plate potential where as many secondary electrons are produced as there are primary electrons, the net plate current is zero. Then as the plate becomes still more positive, the number of secondary electrons produced will exceed the number of primary electrons and the plate current actually reverses.[3] Finally, as the plate approaches its maximum positive value, i.e. the same potential as the grid, the secondary electrons will no longer be attracted to the grid and the plate current again becomes zero. This action is shown in Fig. 5.

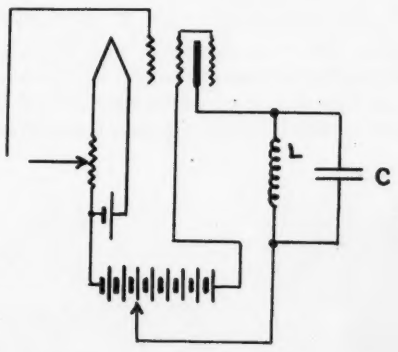


Fig. 6. Here an ordinary screen grid tetrode is used as a dynatron to produce sustained oscillations in the L-C circuit

The peculiarity of that part of the curve from E to G is the basis of the action of the dynatron; an increasing plate potential results in a decrease of plate current. This portion of the characteristic therefore exhibits the property of what is known as negative resistance. The dynatron's action is very similar as that of an ordinary triode with regenerative coupling of input to output circuit and it may be used for similar purposes.

It is possible to use the secondary emission effect and add a normal control grid as well. It may be recalled from the discussion presented in Part XIII[4] that the plate current of an ordinary screen grid tetrode reverses at the lower plate voltages, just as does the current represented in Fig. 5. Therefore, by operating the ordinary screen grid tetrode in the region where the plate current decreases as the plate voltage increases, the dynatron characteristics may be obtained in addition to the action of the normal screen grid. A connection which accomplishes this is shown in Fig. 6; oscillations are generated in the L-C circuit. Such an arrangement

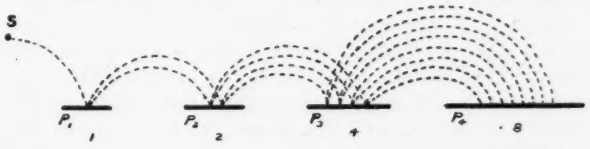


Fig. 7. Showing the basic principle of the electron multiplier

produces particularly stable oscillations and it is frequently used as a source of known adjustable frequency. Its advantages lie in the fact that the frequency of oscillations in the L-C circuit is more independent of changes in the tube parameters than in any other simple circuit.

In a more recent development, the principle of secondary emission is used in an ingenuous manner to produce amplification of current to an almost unbelievable degree. This refers to the electron multipliers of P. T. Farnsworth and V. K. Zworykin in their researches in television. The actual methods by which these two investigators achieve their results differ somewhat but in principle the methods are similar. In Fig. 7 consider S to be a source of electrons. These electrons are drawn to a plate P_1 where they cause secondary electrons to be emitted sometimes in the ratio of 8 or 10 to 1 compared to the primary electrons. These secondary electrons are then drawn to a second plate p_2 where they again produce a batch of electrons. In the diagram, for simplicity, a ratio of two secondary electrons to one primary electron is shown but even here, with one primary electron starting at S it will be seen that 8 electrons reach the fourth plate. In practice, as many as 10 or 15 stages may be used, producing a current amplification of 10^{10} or more. All these stages are incorporated in a single small tube.

These few examples, describing the uses of tubes and principles, are presented not so much to impart information on the devices and principles themselves but to show the versatility of the electron tube in all its various forms. If, in citing these examples, we seem to have been partial to the communication field, it is only because the communication field was the first to use and develop the electron tube and numerous applications are available to draw from. Principles made use of in the communication field are equally applicable in other fields and a knowledge of them should serve both as a guide and inspiration in adapting the electron tube for use in other fields.

[3] In this case each primary electron is responsible for the emission of two or more secondary electrons.

[4] March 1937, p. 169.

INSTALLING LARGE

By WILLIAM J. HART, Mechanical Engineer

THE DESIGN and construction of the world's largest 287,500 v. auto transformers, for the Municipal Bureau of Power and Light, City of Los Angeles, in connection with the Boulder Dam Transmission System, in itself was considered quite an engineering feat. Seven transformers of 65,000 kv-a.—self cooled, air blast—were built for this project and weighed approximately 130 tons apiece, when ready for service. Handling weight and equipment of this size in the modern manufacturing plant was of course not much of a task with large capacity overhead cranes and transfer equipment. To transport this same bulk and weight some three thousand miles by rail and then by motor truck to a substation for erection, however, was a matter that did require careful thought and preparation, and presented many special problems.

A transformer tank having the physical dimensions of these units must be built in sections for railroad shipping clearances. For convenience it was desirable to ship the transformer in the bottom section of its own tank as this eliminated necessary transferring of the transformer from a shipping tank to its own at the destination. Many transformers have been shipped in this manner, the top section being bolted to the bottom section by means of flanges provided on the outside of the tank wall. These transformers, however, were different in that the tank sections were designed to be welded together at their destination. This feature eliminates gasket maintenance and provides a one piece tank. However, it was necessary to provide a flange inside the tank in order that the transformer tank could be assembled and tested at the factory for oil leaks and complete electrical and thermal tests. If, at any time, it will be necessary to move the transformer to another location, the weld can be burned off and the flange used to hold a shipping cover. The method of shipping the transformers by rail and the extent to which care was taken to brace them from all possible impacts in shipment can readily be seen by Figs. 1 and 2. Plain flat bottoms on the tanks make it possible to skid the units from the railroad car to an auto trailer. Means of jacking are seen on the lower corners of the tank. A temporary shipping cover is also seen having the stepped contour required by rail clearances.

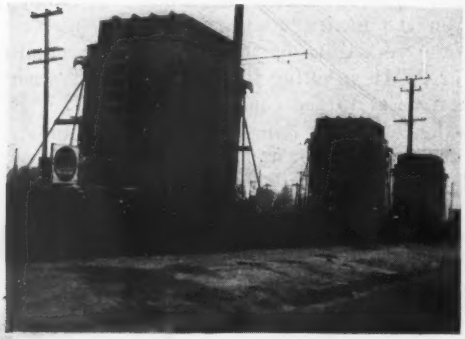
After the transformers were transported to the substation, the actual field erection problems were considered; that is, moving and assembling heavy parts together without damage.

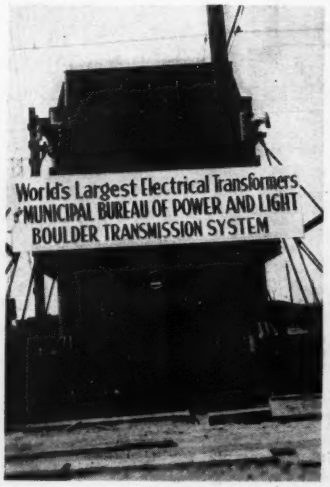
Figure 3 shows the top sections of tanks in the foreground along with a partially completed one in the background; also the large "stiff leg" derrick used for handling all parts.

The top section of the tank telescopes inside the bottom section of tank to a depth of 6 inches where it comes to rest on a flange used to bolt the two sections together. The clearances between walls are approximately 3/16 in. when the sections are bolted together. This gap when welded at the top provides clearances for a rivet head burning torch flame in case it becomes necessary to burn the sections apart.

The first operation therefore was to weld temporary studs to the bottom of the top section of tank, as is shown in Fig. 3, spaced approximately 18 in. apart, the purpose of which was to regulate the 3/16 in. gap by

Figs. 1 and 2. Method of shipping transformer in the lower section of tank on a special low depressed railroad car. Fig. 3. Top section of transformer tank being prepared for assembly





POWER TRANSFORMERS

Westinghouse Electric & Mfg. Co.

applying clamps to the outside of the tank and tightening the nuts on the studs. These clamps also made it possible to align the holes for bolts of the internal flange. When the studs had been welded to the tank and the paint removed, where welding was to be done, the shipping cover was removed and the top section installed, as shown on Fig. 4. The gap could then be welded. It was very important to regulate the gap and to see that it was not closed by the welding heat and distortion. Step welding of numerous stringer beads was employed with a welder on each side of the tank, welding from the center to each corner in order to drive the distortion into the corner. The corners were welded last in all cases and each layer was peened lightly to improve the weld density and increase ductility. This telescoped girth seam was welded completely by qualified operators with covered electrode. Due to the distance from the ground a staging had to be erected to form a level for welding, peening and testing. Tapped holes in the outside wall gave means of applying an 80-lb. per sq. in. air pressure between the internal flange and the outside weld. Leaks were detected by means of the soap and water test while under pressure.

One of the most important problems connected with the welding of this girth seam was the joining of plates together that had a large different thermal gradient. With the telescoped section, one plate was entirely in air and the other plate had a large volume of cold oil on the opposite side. This condition made it necessary to increase the welding current to compensate for the heat that the oil carried away, while on the other hand not too high to seriously damage the plate exposed to air. The welding of this $\frac{5}{8}$ in. wall was carried out without any trouble and practically no distortion, which was remarkable for this type of joint and size of structure.

Other field problems not heretofore encountered were found in filling the tank with oil under vacuum in order to vent all the trapped air in the insulation and oil.

Handling a 287 kv. condenser bushing from a horizontal position to a vertical position and installing it at a 10 deg. angle requires patience and skill with a 50 foot "stiff leg" derrick.

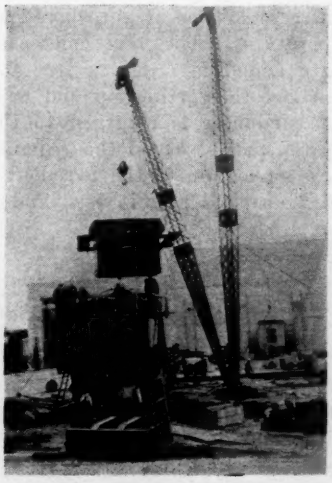
In Southern California, where these transformers are installed, it is quite warm during the day and cool in the evening, hence the cool night air causes a condensate to form.

If the core and coils were exposed to this condition damage to the transformer would result. It is therefore necessary, whenever the nitrogen is released by removal of the shipping cover, to get the transformer under oil as quickly as possible; hence considerable labor must be done between sunrise and sunset.

This means that it is necessary to remove the shipping cover, clean all flanges, assemble top section, cover and bushings before sunset of the same day. As can be readily seen, this requires close figuring and budgeting of hours and men.

It was not possible to inspect the transformers, as is shown on Fig. 5, with the "stiff leg" derrick, due to capacity. However, some weeks later a gantry was available and is shown on Fig. 5.

As can be seen by the photos, there is a vast difference between installing the power transformer of today as compared to those of earlier days.



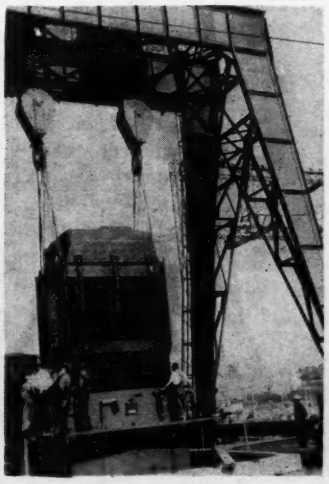
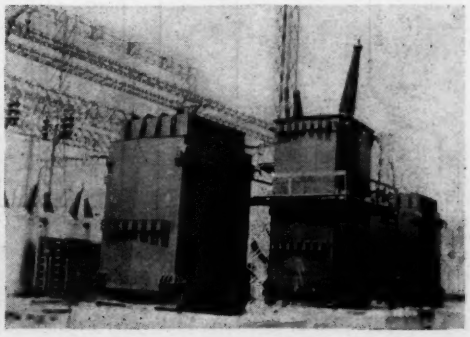


Fig. 4. Assembling top section of tank to bottom section containing transformer. Fig. 5. Removing 65 ton transformer from complete tank for inspection. Fig. 6. Center transformer ready for girth welding and radiators



Process Heating

Use of Dowtherm advantageous on processes requiring temperatures of from 400 to 700 deg. F.

MANY PROCESSES require the application of heat which in the past has been met largely by the use of steam by direct or indirect application. For temperatures up to 350 or 400 deg. F. this is entirely satisfactory inasmuch as the saturation pressure of steam for 400 deg. F. is only about 250 lb. A number of processes, however, require higher temperatures which involve excessive steam pressures, greatly increasing the first cost of the boiler and heater equipment. In any event the use of steam is limited to a temperature of not over 700 deg. F. regardless of the maximum pressure that may be used, but practical considerations set the limit much below this.

To take care of these higher temperature requirements a number of Dowtherm applications have been made. Dowtherm A is fluid at 54 deg. F., has a boiling pressure of 500 deg. F. at atmospheric pressure and at 750 deg. F. has a vapor pressure of but 135 lb. gage. It is non-corrosive, non-poisonous, and, as shown by Figs. 1 and 2, the application and operation of the system is simple.

Figure 1 shows the diagrammatic application as used for deodorizing a vegetable oil. Dowtherm vapor not only heats the deodorizing tank but supplies superheated steam for direct injection. The boiler as shown diagrammatically is fired by a single horizontal burner at one end of the furnace and the thermal efficiency is said to be about 70 per cent. In the installation shown, gravity boiler feed is used, although in some applications where sufficient static head is not available, centrifugal feed pumps are used.

A somewhat similar installation used for heating asphalt is shown by Fig. 2. Dowtherm systems may

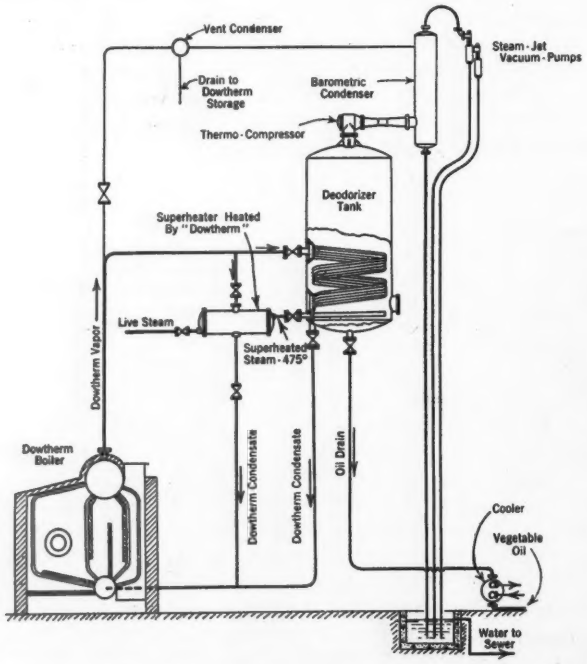


Fig. 1. Application of Dowtherm heating for deodorizing vegetable oil

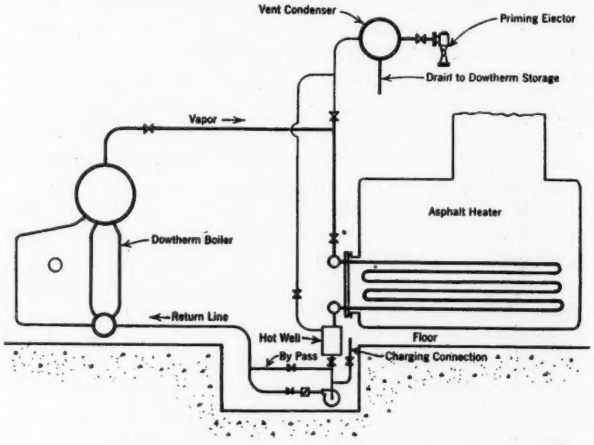


Fig. 2. Arrangement for processing asphalt

be operated under pressure or under vacuum, depending upon the temperature requirements of the process and as with steam systems it is possible to have the vapors heat several different kettles or autoclaves requiring different temperatures. The vent condenser and priming ejector are added in order to free the piping system from air before starting up and condensate from the vent condenser is returned to the Dowtherm storage. In the case of Fig. 1 this priming is done by an auxiliary connection to the barometric condenser, but in Fig. 2 no condenser is used and a special priming ejector is necessary.

FOR Dominion Engineering Works of Quebec, the Canadian Cast Foundry Co. of Montreal furnished an alloy steel casting with 0.2 per cent carbon and 1 per cent nickel for a hydraulic turbine runner, the casting weighing 110,000 lb. and finished runner 65,750 lb. The nickel alloy was used to improve mechanical properties, avoid foundry difficulties due to the intricate shape and eliminate the necessity of annealing.

Corrosion in Refrigeration Plants

Solution of practical problems which confront the refrigeration engineer*

By DAVID W. HAERING,
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REFRIGERATION ENGINEERS are naturally interested in brine and in the proper pH values to prevent corrosion. Work and experience in the field and laboratory has indicated a pH between 8.0 and 8.5 for calcium chloride brines, 8.5 to 9.0 for sodium chloride (salt) brines and 6.5 to 7.0 for calcium magnesium chloride brines as the most desirable range. Some workers prefer values near seven for calcium and salt brines but my experience indicates 8.0 to be a minimum value desirable under ordinary conditions. Many engineers use phenolphthalein as a reagent and since this indicator changes at a pH of 8.2, any color at all with phenolphthalein indicates values well above 7.0.

Occasionally, ammonia contamination causes brine alkalinities to rise sharply and it is necessary to reduce pH values. If the brine has not been treated for corrosion control, chromic acid, phosphoric acid or acid chrom glucosate should be used for that purpose. Carbon dioxide introduces a corrosive gas and may cause appreciable calcium carbonate deposition, so hydrochloric or muriatic acid should be used in preference to carbon dioxide. In some cases of severe contamination it will be found most economical and practical to discard the brine.

Brine which is exposed to the air, particularly if agitated, will drop in pH values rapidly. Carbon dioxide leaks will also cause rapid reduction of pH values and electrolysis or voltaic couples may have the same effect. The term electrolysis in its correct interpretation refers only to current leakage from an external source, but voltaic couples may have similar effects due to the difference in potential between dissimilar metals, or, rust and scale deposits in contact with a metal.

Changing pH Values

Rapidly changing pH values due to air contamination represent a problem in plant control. In calcium brine, suspension of a tray of hydrated lime, frequently answers the problem, although it may be responsible for the introduction of a scale problem. In magnesium and salt brines, daily testing and addition of caustic soda, sodium glucosate or sodium silicate may be necessary.

Corrosion control in brine systems depends entirely on the use of film inhibitors. An effective protective film must be adherent, impervious, elastic, self repairing and self stopping. Sodium dichromate, sodium phosphate, sodium silicate and sodium chrom glucosate are used for this purpose. Sodium phosphate is expensive and uncertain, sodium silicate is erratic and often times objectionable. Sodium dichromate enjoys A.S.R.E. approval, but the film protection is only effective above pH 7 unless the quantities in use are increased materially. The film is brittle and grows properties which may increase localized corrosion and insulating effects. Sodium chrom glucosate is a reliable film inhibitor. Small quantities are employed and the film is impervious and protective from pH 6 to 12.

Scale in brine systems consists chiefly of corrosion products and may be avoided by proper treatment and control of the brines. Calcium carbonate, and oxychloride and magnesium carbonate and hydrate also form brine scale, but controlling the brine at proper pH values will usually prevent such deposits.

Condenser systems present both scale and corrosion control problems. Scale in condensers may often be blamed on living organisms such as the algae and some bacilli and algae that form siliceous sheaths may be responsible for extremely hard formations. Some bacilli forms slime which acts as binder for suspended or precipitated materials and thus result in scale formations. Corrosion products and iron consuming algae are also responsible for certain types condenser scale formation.

Algae and bacilli may be controlled by chlorination and it is probable that chlorinating apparatus will be standard equipment in future plants. Chlorine alone is removed from water chemically by a variety of materials besides living organisms and, consequently, is hard to control, but chloramines prepared by reaction between chlorine and ammonia, are effective germicides and are not readily removed from the water. Ammonium sulphate and bleaching powder are used to provide chloramine in the water. Ammonia water and high test hypochlorite can probably be used to best advantage and economical proportioning equipment is now available for their continuous proportionate introduction. Satisfactory elimination of algae and bacilli can only be obtained through continuous treatment maintaining a residual chlorine content of about 0.2 p.p.m., at all times. Intermittent introduction is not satisfactory and only continuous introduction warrants the consideration of those facing an algae scale problem.

Corrosion in Condenser Systems

Corrosion in condenser systems is often severe and is largely influenced by flow conditions. Turbulence causes marked acceleration of the corrosion rate in any aqueous system and inlet end tube failures are largely due to this factor. Oxygen is the major corrosive constituent of all water but oxygen control is impractical as a means of corrosion control in condensers, and film inhibitors must be employed. Chrom glucosate is valuable for corrosion control in these systems and also inhibits algae and bacilli growths.

Scale in condenser tubes may be due to ordinary chemical formations without the assistance of living organisms, but due to the relatively low temperatures these are not likely to be serious in the absence of corrosion products which will act as binder. Very hard natural waters should be softened or treated internally

*Abstract of paper presented before the N. A. P. R. E.

to avoid excessive scale formations. The treatment considerations are almost identical with the requirements of internal combustion engines.

Jacket Scale

Increasing use and application of the internal combustion engine justifies a few remarks regarding the cooling systems of such equipment. Carbonate, sulphate and silica scale depositions will occur in these systems. Hard natural waters should be softened by the lime soda or zeolite process followed by internal conditioning. Moderately soft waters may be handled entirely by internal methods. Oil contaminations are sometimes responsible for appreciable scale formation and cooling waters should not carry high alkalinities which saponify oil readily and prevent separation. Sludge formations are generally objectionable in these systems and internal conditioning should strive to avoid heavy precipitates.

Corrosion is frequently a severe problem in this type of equipment. Widespread use of zeolite softening without supplemental treatment has been responsible for many corrosion troubles, but the cooling system itself with repeated aeration and turbulent flow conditions increases the severity of the corrosion problem. Oxygen, carbon dioxide, chlorides and sulphides are the chief corrosive constituents of these waters. The corrosive characteristics of the sulphide ion makes it particularly damaging, whether the sulphide is present as hydrogen sulphide or sodium sulphide. If at all possible, the sulphide ion should be removed from the water by conversion to hydrogen sulphide and subsequent aeration.

Cooling System Concentration

Few engineers would think of operating boilers today without some form of concentration control, but too often cooling system concentration is completely ignored. High soluble concentrations invariably increase the corrosion rate and the chloride ion with its solvent action on protective coatings is particularly objectionable in high concentrations.* The concentration limits will vary with different conditions, but in all cases, a competent authority should be consulted and the dissolved solid concentration kept within the prescribed limits. Most cooling systems are not designed to offer efficient blow down facilities, but this will be corrected as operators become more familiar with its importance.

Corrosion control in internal combustion engines must be based on the use of film inhibitors as oxygen removal would be impractical and expensive. pH values of the order of ten should be maintained wherever possible but higher values may lead to oil troubles. Here, chrom glucosate has provided the answer to a difficult problem. Chrom glucosate and concentrations should be maintained between 10 and 20 p.p.m.

Corrosion problem in air conditioning systems is one of increasing importance. Industrial atmospheric conditions introduce such corrosive elements as oxygen, carbon dioxide, sulphur dioxide and hydrogen sulphide. The increasing use of air conditioning methods and the resulting trend to cooling towers in order to conserve water increases the magnitude of this type of corrosion problem. Gas control by mechanical or direct chemical reactions is obviously impractical for these systems. pH adjustment although helpful is expensive for the small reduction in corrosion rate that it accomplishes. Film inhibitors such as dichromate, silicate and phosphate have been employed but are not entirely effective and in many cases cannot be used because windage losses may result in damage to neighboring property. Materials used in treating wash water must not impart any undesirable characteristics to the air. Chrom glucosate is used successfully in handling the corrosive conditions of these systems but materially larger quantities are necessary than in the other systems.

Boiler Feedwater

No discussion of corrosion can ignore the subject of boiler feedwater conditioning. Siliceous scale formation is receiving considerable attention today and soft siliceous waters in certain areas have always presented a difficult scale problem. These waters are similar chemically to zeolite softened water and a similar scale problem exists with the softened water. Siliceous depositions are now positively controlled through the application of beta glucoside maintaining silica chloride ratios equal to or greater than the raw water ratio.

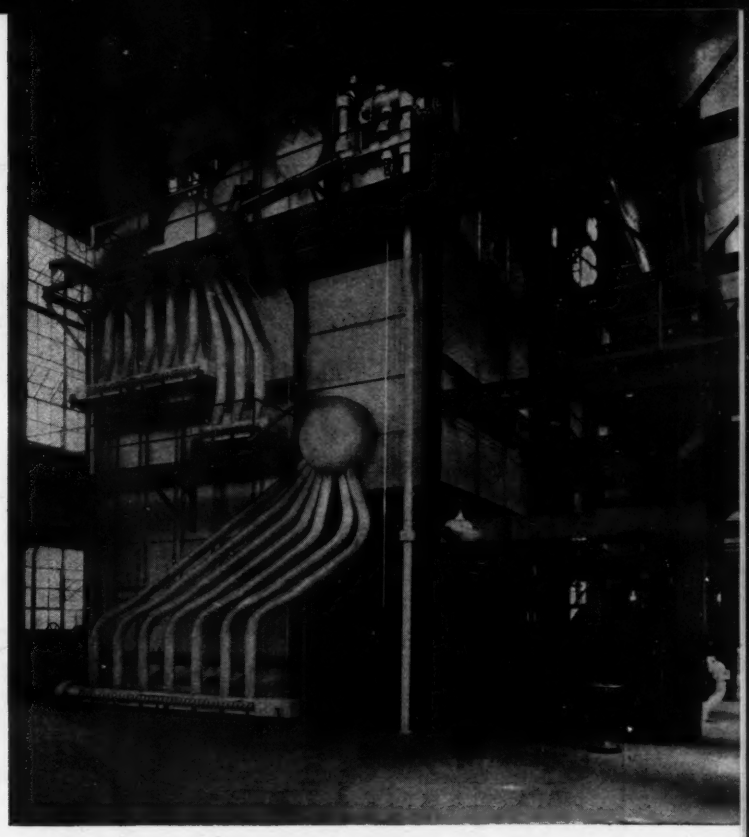
Feedwater contamination with fuel oil is becoming a common occurrence resulting from the increasing use of oil burners. Leaks in oil heaters result in a severe contamination that may result in serious damage. The use of a chromium steel alloy in preheater construction would eliminate this hazard but, except in special cases, this protection is seldom available.

Remarkable advances have been made in chemical control of oxygen. Sodium sulphite and sulpho glucosate are both efficient chemicals which remove oxygen by direct reactions. In cases of boiler water carrying appreciable amounts of calcium ions, the introduction of sodium sulphite may result in a tendency towards calcium sulphate scale formation. The sulpho glucosate does not exhibit this tendency and may also be used to condition hot water.

Corrosion from Concentration Cells

There is one type of corrosion that I wish to mention before closing. Concentration cells cause corrosion in exactly the same manner as voltaic couples between dissimilar metals. A dilute solution is anodic to a more concentrated solution and an aerated solution is cathodic to a deaerated solution. This fact is responsible for a large part of the corrosion occurring in idle boiler equipment and a number of cases of severe corrosion have come to my attention in heating plants which failed to wash out boilers for a couple of months after the spring shutdown. In an idle boiler, the surface of the water will become oxygenated and cathodic to the layer immediately below with the result that corrosion starts in the anodic area immediately below the water line. As the corrosion products fall to the bottom of the boiler, the lower body of water will become more concentrated and cathodic to the upper layer. Corrosion will then be accelerated with the result that severe pitting just below the water line may take place in a short period of time. Boilers should not be permitted to stand idle unless completely filled with properly conditioned water or completely drained and cleaned with all man holes open to permit free circulation of air.

Jos. E. Seagram & Sons builds new 50,000 gal. per day unit at Louisville, Ky. Served by two 528 hp. 400 lb. pulverized coal fired boilers and two turbo-generators



Seagram's Distillery at Louisville

By

W. L. FRASER, Chief Engineer
Seagram's-Distillers Corporation

KENTUCKY has long been the traditional home of good whiskey and the new unit of Jos. E. Seagram & Sons at Burnham Lane and Seventh Street Road in Louisville was built to carry on that tradition. Not only has years of experience been combined with modern developments to make the distillery the acme of the industry but the architectural treatment is such that the group of new buildings is a distinct asset to industrial Louisville. Very few industries lend themselves better to the generation of by-product power than a distillery and this is especially true when there are large warehouses to heat, when slop is dried and made into cattle feed, and when provision is made to store a large quantity of hot water for process work.

This new plant is laid out in what might be called, in electrical terms, series-parallel, with a single mill building, dryer house, power plant, cistern house and warehouse serving two separate and distinct distilleries, the Calvert and the Seagram, each with a capacity of 25,000 gal. of whiskey per day. The power house, cistern house and warehouse are connected by a tunnel system sufficiently large to take care of all piping as well as the transport of barrels from one building to the other underground.

As shown by the flow diagram, Fig. 5, four steam pressures are used. The main steam turbine operates between the 400 lb. boiler pressure and 90 lb. process system. The coal pulverizer and forced draft fan turbine drives operate between the 400 lb. and the 10 lb. system. The 90 lb. system supplies the mash tubs, doublers, process water heater, warehouse heating, and the boiler feed and hammer mill turbine drives while the 10 lb. system is for the beer and water stills and boiler feedwater heater. The pulverizer and forced draft fan turbines are between the 400 and 10 lb. pressures.

In emergency operation the 550 kw. standby turbine is supplied with 90 lb. steam through a reducing valve and exhausts into the 10 lb. line while the dryer house at all times uses 125 lb. steam also supplied from the 400 lb. header through a reducing valve. Both turbines are protected by Cochrane multiport relief valves, constant and overspeed governors. Fisher reducing valves are used throughout and, in addition to those mentioned above, individual reducing valves and relief valves connect the 400 and 90, 90 and 10 systems to maintain a constant pressure from the next higher system.

The power house has two 528-hp., 400 lb., Vogt boilers, each fired by a 5 t. Riley mill and a total generating capacity of 1300 kw. in the two Westinghouse turbo-generators mentioned above. Each boiler has a Clarage individual forced draft fan located in the

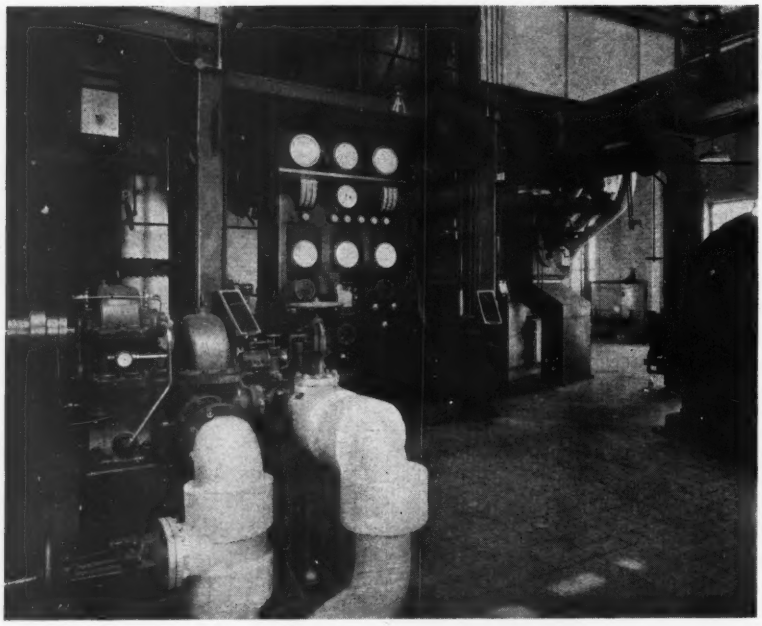


Fig. 2. Operating floor with the control panel located between the two boilers. The forced draft ducts to the burners, primary air ducts to the mills, the mill drive, water column mirrors, sifting hoppers and dust conveyors are all visible

basement with the three Worthington boiler feed pumps and the hotwater heaters. In general the auxiliaries are driven by Elliott turbines.

Coal received by rail is handled by a complete 30 t. per hr. Fairfield coal handling system. The 12 by 12 ft. steel track hopper is screened by a steel grating with 10 in. square openings. Coal from the hopper is delivered by a 24 in. steel apron feeder, through a double roll crusher, to an 18 in. belt conveyor which discharges over a Dings magnetic pulley to a V-bucket elevator made up of 16 by 15 in. steel buckets mounted on two strands of steel roller chain. This conveyor discharges, through four gates in the horizontal run, to a 290 t. suspension bunker.

In contrast to the other auxiliaries the coal handling equipment is electrically driven by 440 v. Westinghouse motors. One 15-hp. motor drives both the crusher and feeder, a 2-hp. motor the belt conveyor and a 10-hp. motor the V-bucket conveyor. The bunker, enclosed at the top with all chutes and connections made dust tight, is provided at the bottom with two tapered chutes to reduce the dead storage to a minimum. This construction shows up clearly in Fig. 1. Each chute, fitted with a totally enclosed drip and sift proof, roller rack and pinion gate delivers coal through an enclosed automatic Richardson scale to each pulverizer.

Each of the 5 t. Riley pulverizers, driven by a 75-hp., 385 lb. Elliott geared turbine exhausting to the 10 lb. system, supplies two burners on a single boiler. The four drum Vogt boiler is fired from the lower side with the burners immediately below the mud drum and is baffled for three passes. As shown by the plan drawing the center lines of the two burners mounted as the back wall converge near the center of the 4400 cu. ft. furnace, to minimize impinging action of flame on the side walls. The setting is unusually interesting. The front wall, 13½ in. of fire-brick and 9 in. of common brick, is solid but the other three walls are completely water cooled with 4 in. tubes set on 4½ in. centers giving a total projected water wall surface of 1795 sq. ft. Backing the water walls are 3 in. of refractory tile, 3 in. of rock wool insulation and a 10 ga. steel casing. The side wall circulators from the mud drum, and, risers to the steam drum, are clearly shown by the photograph. For lighting up, steam atomized oil burners are provided, the burners being inserted through the center of the powdered-fuel burners and permanently installed. They are of ample capacity to carry separately a considerable portion of the boiler rating in emergencies.

Sloping hopper bottoms are air cooled and discharge directly to a United Steam jet ash conveyor system. The conveyor openings are screened from the furnace by the special construction shown by the cross sectional drawing which reduces the head room necessary in the basement and allows emergency removal of ash through regular doors. The ash conveyor system also handles the siftings from the hopper at the bottom of the second pass of the boiler through the cast iron line shown just under the gallery grating of Fig. 2.

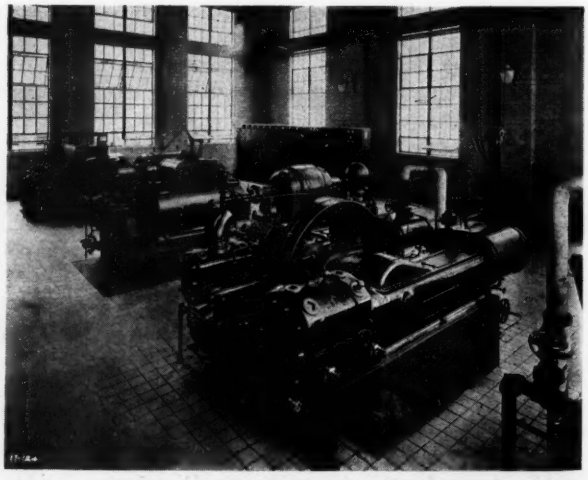


Fig. 3. The turbine room with the 750-kw. turbine and switchboard in the background

Each boiler is equipped with Yarnall-Waring Yarway blow off valves, Diamond soot blowers, Northern Equipment Co. Cope's feedwater regulators, Reliance Tiltview gage glasses, Powell non-return valves, Permutit continuous blow off and Consolidated-Ashcroft-Hancock safety valves. In general, Crane fittings, Powell valves, Strong, Carlisle and Hammond traps, Philip Carey insulation and Blaw-Knox Electroforged grating were used throughout the power plant. Copper pipe is of course widely used throughout a distillery where corrosion and contamination must be avoided, and it is interesting to note that in this plant all drain pipes are copper as well, with Mueller fittings.

Combustion is controlled by a Cash automatic system. In general, a master controller actuated by main steam header pressure directly regulates the coal feeders to the pulverizers and indirectly regulates the burner wind box air pressures through remote adjustment air controller. Each such control directly operates the forced draft fan outlet damper and indirectly regulates the speed of the fan turbines. The system also includes a furnace draft controller actuated by furnace pressure and directly operating the individual boiler uptake flue dampers, so as to maintain the correct constant draft within each furnace throughout the full boiler load range. CO_2 is kept around 15 per cent and flue gas temperature rides around 650 deg. F. at 300 per cent rating while the heat balance showed a total incomplete combustion loss of 2.5 per cent. The boiler control panel, located between the two boilers has, in addition to the combustion control equipment, Hays three pointer draft gages, Cochrane feedwater and steam flow meters and a Brown CO_2 and uptake gas temperature recorder. A 250 ft. reinforced concrete stack, 12 ft. diam. at the top, releases the combustion gases and dust at a safe enough height to prevent fly ash from settling in immediate vicinity of plant.

Water for the distillery and for boiler feed make up is supplied from three 1200 g.p.m. Cook deep well pumps. All water is first acid treated neutralizing the alkalinity from 280 p.p.m. to 160 p.p.m. This system of Permutit design has so far kept all domestic and process water lines remarkably clean of lime deposits. The boiler feed is partially made up of condensate returned from the various units in the distillery to a storage tank in the basement and from this tank pumped into a special heater which is part of the hot process lime-soda softener, taking steam from 10 lb. system.

Two Worthington Monobloc centrifugal pumps each driven by a 7½-hp. Master motor handle this condensate through Fisher float controls. Make up amounting to about 80 per cent of the total feed is passed through a Worthington vent condenser and a deaerating heater into the softener. The water which issues from the softener, still contains about half a grain of hardness so a supplementary phosphate treatment is required. An excess of 65 to 85 p.p.m. PO_4 is maintained in the boilers at all times to insure zero hardness. After settling all water is passed through calcite filters which remove last traces of oil and other impurities before passing to the boiler feed pumps. About 5 per cent of concentrated boiler water is continually blown down through a Permutit flash system deconcentrator, whereby about 25 per cent of the heat is recovered as steam

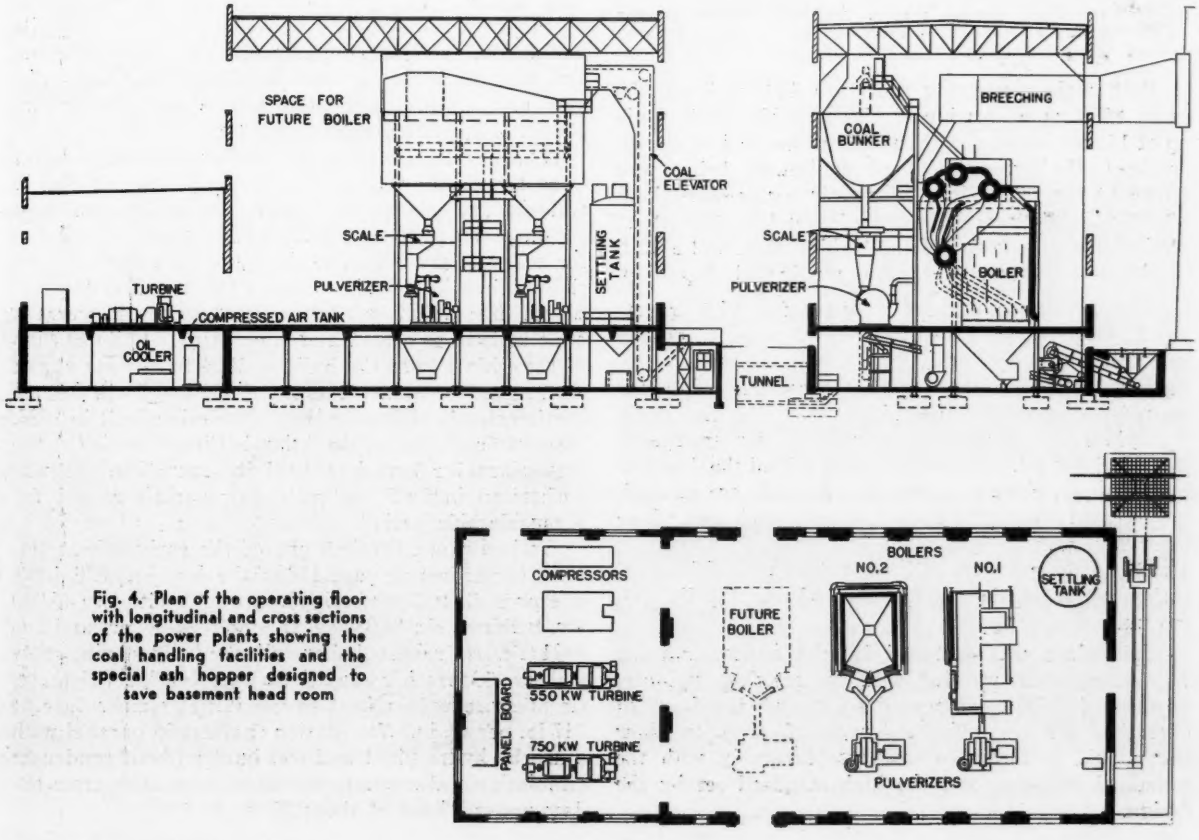


Fig. 4. Plan of the operating floor with longitudinal and cross sections of the power plants showing the coal handling facilities and the special ash hopper designed to save basement head room

to the 10 lb. exhaust system. A heat reclaimer was omitted because there is an excess of hot water most of the time from the condensers and coolers.

The three 3600 r.p.m. Worthington feed pumps, rated at 165 g.p.m. at 1200 ft. head, are located in the basement near the elevator shown in the lower right hand corner of the plan drawing. One of these pumps is driven by a Westinghouse 100-hp. motor, and two by 88-hp. Elliott turbines taking steam from the 90 lb. system and exhausting to the 10 lb. system. The two Stedman hammer mills in the mill building are also driven by 86-hp. turbines operating under the same steam conditions.

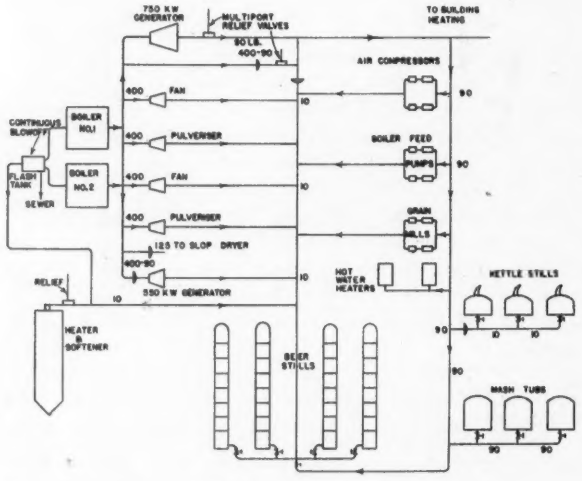


Fig. 5. Steam flow diagram showing the four different pressure systems

Both main generating units are 440 v., 3 ph., 60 cycle, 3600 r.p.m. machines. The switchboard is made up of 14 steel cubicles with manually operated oil circuit breakers, the arrangement of equipment being well shown on the plan Fig. 1. Two air compressors, both Ingersoll-Rand steam driven, one 500 and one 250 c.f.m., are installed in one end of the turbine room and a 10 t. Chisholm-Moore crane facilitates repair and inspection.

Fire fighting apparatus consists of a 1500 g.p.m., 230 ft. head Dayton-Dawd centrifugal pump driven by an Elliott 140-hp. turbine. This pump is directly supplied from a 150,000 gal. storage tank while the sprinkler system is connected direct to the city main. A 500,000 gal. pond is also available for emergency and a 125,000 gal. tower tank stands behind the domestic water supply. Four hose reels 500 ft. each, are strategically located around the plant in special reel houses where other fire fighting equipment is also kept. There are also 176 (2½ gal. soda and acid) fire extinguishers, 37 carbon tetrachloride quart units and ten 7½ lb. CO_2 gas units.

This plant was designed by the author and his engineering staff, working with the erecting engineers of firms furnishing the equipment and has been in operation for a sufficient length of time to show that actual performance compares favorably with the estimated efficiency and the high standard set by the design.

Reheat Is Not Dead

Twin Branch 2500 lb. 940 deg. F. Extension with 62,500 kw. Cross-Compound Turbine, Authorized by American Gas & Electric Co., Will Set New Record. Natural Circulation Boiler to Be Fired by Pulverized Coal

ANNOUNCEMENT of a 2500 lb. 940 deg. F. extension to Twin Branch Station of the Indiana & Michigan Electric Co. at Mishawaka, Ind., again confirms the position of the American Gas & Electric Co. as a leader in the field of power generation and places the reheat cycle as an active competitor of the moderate pressure-high temperature straight through cycle for new power plant construction.

This pressure is practically double that of most modern plants and the temperature is higher than that used in any plant now in service. Although higher pressure plants have been built in Europe they have been of comparatively small size, all of them with forced circulation boilers as contrasted with the natural circulation boilers which will be used in the Twin Branch Station, 2500 lb. being considered the limit for which natural circulation boilers can be built.

Contracts for the major equipment have already been signed. The new boiler and pulverizers will be supplied by the Babcock & Wilcox Co., the 3000 lb. per sq. in. boiler feed pumps by the Ingersoll-Rand Co., and the turbines, 2400 lb., 22,500 kw. high pressure unit cross compounded with a new 40,000 kw., 400 lb. unit, by General Electric Co.

This development has been under consideration for some time and was accelerated by the recent rise in material and labor costs. It is quite in line with past advances made by the company, however, which has for many years been one of the most progressive in the public utility field. Some of the more outstanding plants are: Windsor Station of the Ohio Power Co. built in 1918 as a mouth-of-mine plant. Philo Station of the Ohio Power Co. built in 1924 to operate at the then record breaking pressure of 650 lb. Twin Branch Station closely following the Philo design built in 1925. Deepwater Station of the Atlantic City Electric Co. the first plant for complete 1250 lb. operation. It was authorized in 1928 and held the world's record for a considerable period.

Twin Branch Station, one of the early reheat stations (described on page 118 of the Jan. 15, 1926, issue of Power Plant Engineering), was built with two 35,000 kw. turbines, six 14,086 sq. ft. standard boilers and one 5031 sq. ft. reheat boiler, all fired by chain grate stokers. Operating conditions were 650 lb., 725 throttle pressure with reheat to the initial temperature at 147 lb. per sq. in. The station operates in parallel with a nearby hydro plant and was built without condenser circulating water pumps as water is available from the dam under a head of about 25 ft.

Welded Steel Stack at Fisk Station

SEVERAL innovations are incorporated in the new welded steel stack to serve the topping unit at Fisk Station of the Commonwealth Edison Company in Chicago, a type of construction comparatively new in this field. The design of the girth joint used is employed here for the first time, and in size, this stack sets a record for welded construction.

In constructing the stack, the base is anchored by means of four vertical beams inside the stack, to a ring girder which rests on structural girders in the upper part of the boiler house. From this point the stack is 219 ft. 9 in. high or 300 ft. above the city datum, the inside diameter being 13 ft. 10 in., lined with brick from bottom to top. The steel shell and welding rings are of mild steel, the thickness of the shell being $\frac{5}{8}$ in. for the first 38 ft., $\frac{1}{2}$ in. for the next 67 ft., $10\frac{1}{2}$ in. and $\frac{3}{8}$ in. for the remaining 113 ft., $11\frac{1}{4}$in. The total weight of the steel used is 124 t., and of the brick 225 t.

Some of the details of the stack design are of especial interest because they are used here for the first time. The girth joints are designed especially for this job. The plate sections were formed in the shop, varying from 6 ft. 0 in. to 7 ft. 6 in. high and of sufficient length to extend one-third way around the finished stack. At the top of each plate was welded a 4 by 4 by $\frac{1}{2}$ in. T ring with the cross part or flange of the T on the

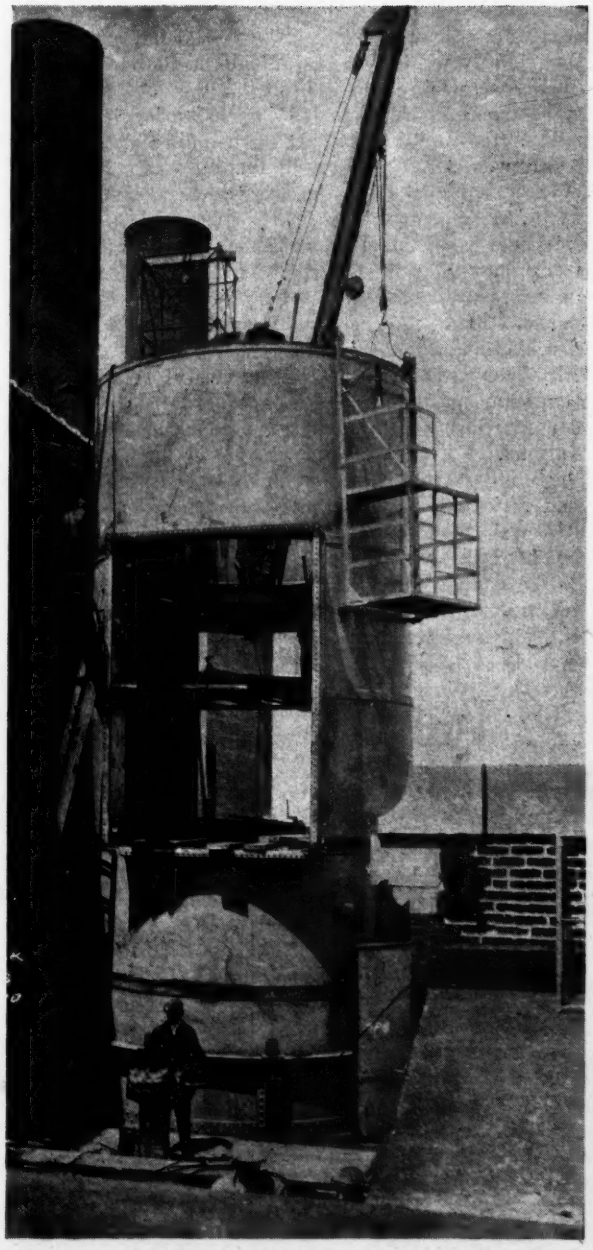


Fig. 1. Base of the stack showing ring girder, equipment used in hoisting plates and one of the welders' cages

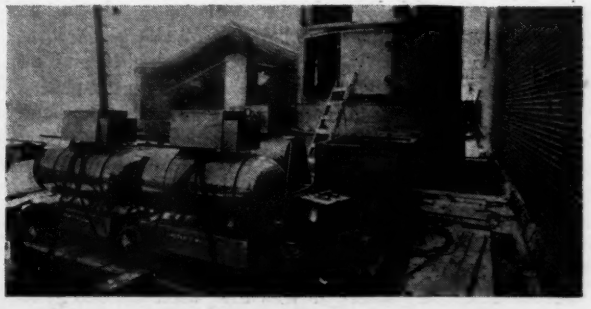


Fig. 2. Welding equipment used in construction work

Fig. 3. First courses of stack lining

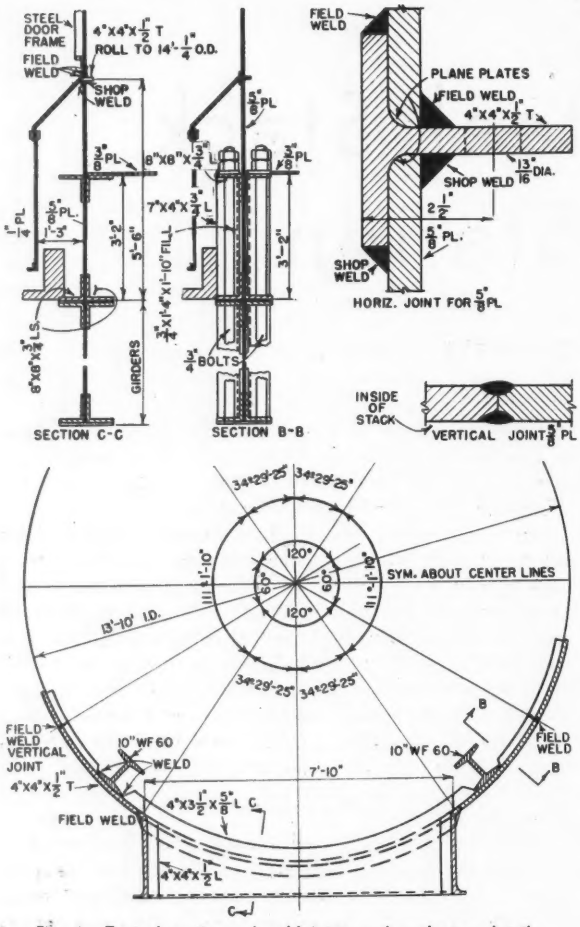


Fig. 4.—Typical sections of weld joints and anchoring details

outside of the shell, thus providing two welding seams between the T ring and each plate and a supporting shelf at each joint for the brick lining. By performing a portion of the welding in the shop, down-hand welding was possible on all seams of the girth joints. The vertical joints were welded both inside and outside, the seal being described technically as 2-pass, 75 per cent and required no calking whatever.

As construction progressed the plates were hoisted into place, three being required for each ring, the lower side of the plate rested upon the stem of the T ring, welded to the plate all ready in place, then forced into position against the flange of the T by means of wedges and rods through holes provided in the stem of the T rings. There it was first tack welded; then, when the ring of plates was in correct adjustment, the joints were permanently welded into a solid leakless seam.

The strain on this joint is nearly always of the compression type except when this strain is relieved by wind pressure, when it turns to tension. The compression strain does not depend in any way upon the welded seam for its strength, the tensile strain does, however, but tests have been shown that joints of this type are well able to withstand all probable strains.

Vitreous shale paving brick was used for lining the stack, selected because it is practically impervious to moisture. This brick is set with portland cement mortar with a 1-in. lining of cement between the shell and the brick. To the cement was added an admixture for the purpose of waterproofing the cement, also retarding its setting and making it easier to handle. A coating of gunnite is used to cover the short vertical beams that anchor the stack to the ring beam. Experience has shown that with this lining, to prevent moisture reaching the inside surface of the shell, the corrosion of the steel is to be greatly reduced, if not completely eliminated. As the welded seams were completed they were covered with aluminum paint, the entire metal surface being given a coat of blue lead paint, the final finish of the outside surface being a coat of black graphite paint.

Access to the top of the stack is gained by means of a steel ladder welded through connecting plates to the outside of the stack. In construction, the ends of rungs are passed through holes in the side pieces and then solidly welded on the outside of the ladder.

In performing the welding on the job, three 400-amp. machines were used. They were located on the roof of the building with cables running up the stack to the welders. Considerable trouble was encountered with wind blowing out the arc, which necessitated the use of sheet iron shields on the cages. The electrode used was a slag-shielded welding rod. Records of the work show that it required 0.132 kw-hr. of electric power to weld 1 linear ft. of 2-pass weld, 0.709 kw-hr. per man-hour; the speed of welding was 5.36 linear ft. per man-hour of 2-pass weld on ½ and ⅜ in. plates. All this work was done under careful visual inspection, and not a single accident occurred during the construction, which started April 17 and was finished July 29.

It is reported that this stack has unusual rigidity and resistance to wind pressure. One important feature was the specially designed joint which permitted much of the fabrication to be done in the shop.

Graham, Anderson, Probst & White did the architectural work and Sargent & Lundy, Inc., was the consulting engineer on this job.

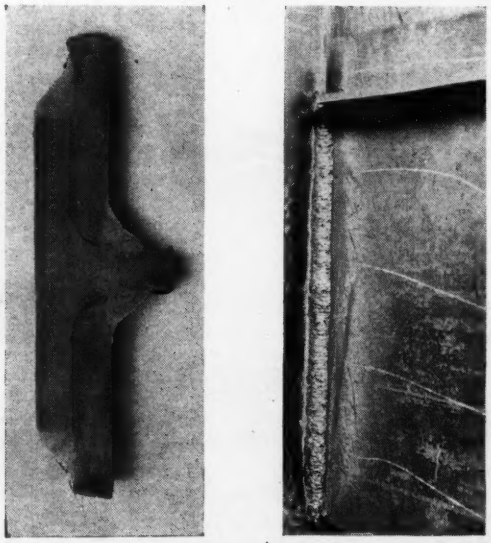


Fig. 5. Left: Welded joint of horizontal type tested to destruction; Right: Vertical welding ring of lap joint plates to angle iron stiffener at first ring of stack

ANALYSES of Flue Gases from Natural Gas Fuels

Discussion involving determination of proper CO_2 and reliability of combustion instruments

By HENRY COONEY

UNDER the title "Flue Gas Analyses Blow up a Storm" an article by J. R. Darnell in the March, 1937, issue reviews articles of the writer appearing in the issues of April and September, 1936. An attempt to answer these criticisms will now be undertaken. The topic of furnace temperatures and refactory maintenance will be referred to first.

The statement of the writer which, doubtless, had most to do with precipitating this "Storm" follows: "Since modern furnaces will withstand the heat of the perfect combustion of natural gas, and since we have burner equipment which will produce such combustion, it would seem that the claim that 15 to 20 per cent excess air should be used when burning this fuel no longer holds."

Mr. Darnell, unlike Mr. Swain, does not question the claim that we may approach perfect combustion in gas furnaces, for he states: "Such operation is, beyond doubt, the most efficient, but it may be far from economical if refractory maintenance is excessive, or, if when water cooled walls are used combustion is retarded at low ratings." Mr. Darnell also admits that air cooled walls will help, but he condemns them because they usually leak. It should be borne in mind when considering these statements that it is difficult to operate any furnace economically at low ratings, that the disadvantages of water walls at low ratings may be more than compensated for by advantages gained at normal or high ratings, that the leakage of furnace walls depends on the furnace pressure, that "19 per cent" is uneconomical, and that with a boiler properly designed and operated, a hot furnace means a cool stack. It is obvious, however, from these admissions that under average operating conditions a properly constructed furnace will withstand this heat.

The theoretical furnace temperature for the gas under consideration (86 per cent methane and 14 per cent ethane) is given by Mr. Darnell as about 3650 deg. F. This value, though a trifle high, is close enough for the flame temperature of this gas. The actual furnace temperature may be a "few hundred" degrees less, but any temperature above 3000 deg. F. is more than "most refractories" will withstand, according to that same author. The expressions "a few hundred degrees" and "most refractories" seem rather vague for a discussion of this sort. From Table I the theoretical flame temperature for 10 per cent CO_2 is 3300 deg. F. and from Table II the excess air is 18 per cent. The question arises, then, would the "few hundred degrees" bring this temperature within the 3000 deg. F. limit. If the temperature of the furnace walls were known to be under this limit, the fact would be of but little significance in installations which are largely manually operated, for, with varying loads it is quite difficult to keep the furnace temperature within bounds. One solution of the problem is to construct a furnace which will meet the exigencies of gas firing, if feasible, and the writer believes it is.

Furnace Maintenance

When considering this problem of furnace maintenance the first cost and the expense of the upkeep of a furnace in which combustion may approach the "ideal" must be weighed against the same items for a furnace designed for around 18 per cent excess air and a complete combustion control system. Probably because the writer's experience has been confined to small units he favors a furnace designed for high temperatures, such as are built into fire-box or locomotive type boilers. A furnace which requires a refractory lining when built for gaseous fuels should be of a somewhat different design from one constructed for solid fuels. The Dutch oven or retort type of furnace has not been found very satisfactory for gaseous fuels.

Let us consider the baffling and burner arrangement of the furnace of a water tube boiler. If the boiler is baffled vertically no change in the baffling would be suggested. If baffled horizontally the tile should be placed on top of the third row of tubes. In either case the tubes are brought into direct contact with the heat of the fuel. The burners should be arranged so that the flame may be brought as close to the tubes as practicable. The flame, of course, should not be close enough to the tubes to cause "banking" of the gases or "floating" of the flame. The sectional multiport type of burner which is placed inside the furnace gives good results. These burners are designed for automatic proportioning of the fuel and air and meet the A.S.M.E. requirement of producing a blue cone without a grid. This arrangement of burners and baffles exposes more of the tube surface and less of the furnace walls to the heat of the products of combustion, gives better heat absorption and reduces furnace wall temperatures.

Furnaces built after this plan and lined with "Alumite" brick are, in several installations, withstanding the heat produced when 11 to 12 per cent CO_2 is carried with a saving in refractory maintenance as compared with operations when 8 to 9 per cent CO_2 was desired and cheaper brick and bonding were used in a furnace of a different design. So the writer is still of the opinion that a well designed furnace will withstand the heat of combustion of natural gas, even when it approaches the "ideal."

Adjustment of Air Flow

Paragraph five of the writer's September article reads in part as follows: "Difficulty is often met with in properly setting the steam flow-air flow meter. If the meter is set from analyses made from an orsat one may fall into the same error that was pointed out by Mr. Swain when considering the CO_2 method."

The method employed for determining the values at which the air flow meter, not the recorder, should be set, follows: [1]To determine the excess air for a given fuel, orsat tests are conducted to determine the composition of the flue products best suited for the installation—refractory maintenance and other factors being considered. The excess air is then calculated from the formula:

$$\text{Excess air} = \frac{O_2}{0.264\,N_2 - O_2}$$

A series of 70 such tests conducted on gas fired boilers gave the average excess air at best operating conditions as 19 per cent. Hence a meter may be set empirically at this percentage.

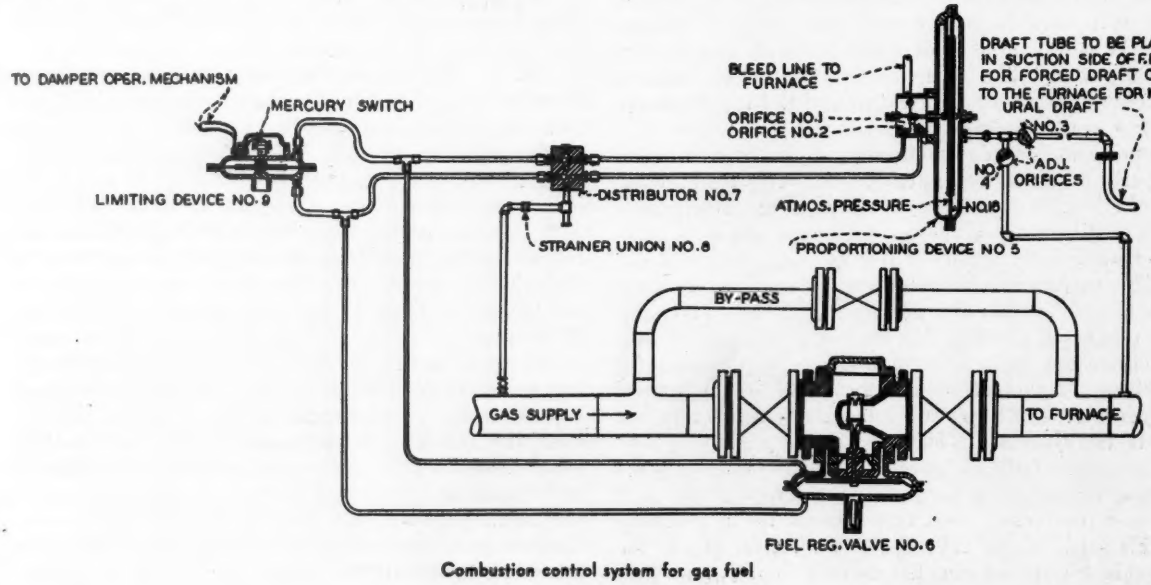
As to the effect of moisture on the air flow readings we quote from the article referred to above[1]. "As shown in Fig. 13 this (the air flow) is substantially constant for all kinds of coal varying with the percentage of moisture, which causes the greatest error in results, as the moisture is an inert foreign vapor or gas, producing a record on the air flow but is not effective in producing steam. It is seen that the greatest error is 4 per cent from the standard with a variation in the moisture of 15 per cent." When a gas containing any considerable percentage of inert gases with its usual quota of moisture is burned, this deviation, it is believed, will be increased. Should a shift be made to a different fuel, the meter, as the writer understands it, could be reset at the plant. Mr. Darnell's plan of having the meter adjusted by the manufacturer whenever a change is made in fuel would be rather inconvenient in some installations.

This characteristic of the steam flow-air flow meter was referred to, not to show that it has no redeeming features nor that it is an undesirable control, but in answer to the objections of Mr. Swain that the CO_2 method was not a dependable combustion guide, although as shown above the air flow meter is set from orsat analyses. A solution CO_2 recorder is nothing more or less than a mechanically operated orsat (the electrical CO_2 recorder is considered just as reliable by many), then why object to its use when, under the conditions assumed in the September article of the writer, a control system was not available?

Those who have read the excellent articles in Power Plant Engineering on "Combustion Control" have, doubtless, noted that several of the control systems also maintain constant excess air at all ratings using a CO_2 or O_2 meter as the combustion guide. One system makes provisions for varying the excess air with the load, so that high excess air may be used at low ratings to insure complete combustion of the fuel and at high ratings to protect the furnace walls. From a description of the new Hiram Walker and Sons' power plant we note that a steam flow-air flow meter and a CO_2 recorder are both used in the combustion system. Considering natural gas fuel alone the writer would, from the standpoint of all around efficiency, prefer the CO_2 to the excess air method, unless, of course, the excess air were maintained at from 5 to 10 per cent.

While the writer in the words of Mr. Darnell has "extolled the virtues" of the CO_2 recorder (he fails to state that I did not forget some of its vices) I have

[1]See article by E. G. Bailey, "Limiting Factors in Reducing Excess Air in Boiler Furnaces." Mechanical Engineering, July, 1926.



Combustion control system for gas fuel

not as yet recommended it as a combustion control system. The facts of the matter are that it would require a control system properly to regulate a CO_2 recorder. I would like to describe in a few words a plan devised for determining which side of the combustion equilibrium the fires are on, when the recorder is showing near the ideal percentage. A solution and a specific gravity recorder are used in conjunction. Assuming that both recorders are showing around 12 per cent, and about 2 per cent O_2 should appear in the flue gases, both recorders will drop to 11 per cent or a little less. If, however, above 1 per cent of CO appears, the solution recorder will continue to show 11 per cent, while the specific gravity recorder will drop to 6 to 8 per cent CO_2 indicating that the air supply is insufficient, calling for a fuel adjustment.

Combustion Formulas

On page 752 of the issue of July 1, 1930, Mr. Darnell gives a series of formulas for calculating the percentages of the several components of the products of combustion of solid fuels. Space will permit reference to only one of these formulas, which follows:

$$M = \frac{21\ (K + k)}{(21 - O_2) + 0.4\ k} \qquad \text{Formula 1}$$

In which M equals the maximum CO_2, K the actual CO_2 and k the actual CO.

This formula was revised by Mr. Darnell, after a study of the formulas of A. A. Bato, so that the factor 0.4k reads 0.395k. Unless extreme accuracy is desired in combustion calculation, which is rare, this revision would have little significance.

Formula 1 was submitted to the Bureau of Mines, Washington, for an opinion as to its applicability to the combustion products formed in natural gas firing. The reply received from the Pittsburgh Station follows:

"The formula you present is an approximation for some types of highly carbonaceous fuels as coke, but it is entirely unsuitable for gases containing hydrogen or hydrocarbons. In such cases no standard formula is available, but each individual case may be solved if an analysis of the fuel and the flue gas is available." Signed, H. H. Storch, Supervising Chemist, Physical Chemistry Section, November 13, 1933.

Although the writer has quite a collection of combustion graphs and formulas, he usually follows a plan somewhat similar to that suggested by Mr. Storch and uses the regular combustion formulas in combustion calculations. The chief reason for using the regular combustion equations, however, is that they are more readily comprehended than the complicated formulas of the combustion engineers. Tables giving all the data pertinent to any gas may be readily constructed from these combustion formulas. Table II is abridged from such a table. Such tables are not only useful to the boiler operator, but they also serve as a handy reference to the orsat operator. In the case cited by Mr. Darnell in which the orsat operator lost his sample after determining the CO_2 and before finding the CO, reference could be made to a table or graph for the information. If, however, CO_2 is present or suspected a preliminary test for "illuminants" should be made.

It might be inferred from the tone of the opening paragraph of Mr. Darnell's article that there was something amiss in the writer's "warning against the use of formulas to calculate the excess air by the use of CO_2 values, taken from the recorder, without considering the amount of oxygen and carbon monoxide present." If there were no oxygen present, of course, there would be no excess air, so it would be necessary to consider that factor. If CO is present in the flue products it is an indication that unburned fuel is present. So if the true theoretical CO_2 value is desired it is a safe plan to secure a sample that does not contain CO. Perhaps this is the reason that the Bureau of Mines and The American Gas Association avoid equations containing carbon monoxide, unless an analysis of the fuel is available.

The equations generally used in the various combustion reaction calculations follow, taking methane as example:

$$CH_4 + 2\ O_2 + 2\ (79.1 \div 20.9) = CO_2 + 2H_2O + (158.2 \div 20.9)$$

$$\text{Per cent } CO_2 = 100 \times \frac{1}{\frac{1 + 158.2}{20.9}} = 100\ (20.9 \div 179.1) = 11.675$$

The following constants may be derived from these formulas:

Volume of the products of combustion dry = 1 ÷ actual CO_2.

Excess air, per cent = Volume, dry, + 1 — 9.56 ÷ 9.56.

O_2 increases 1.791 per cent and the N_2 decreases 0.791 per cent for each change of 1 per cent in the CO_2.

The equation for excess air, again using methane and assuming 10 per cent excess air is:

$$CH_4 + 1.1 \times 2\ O_2 + (1.1 \times 2 \times 3.7847\ N_2) = CO_2 + 2H_2O + 0.2\ O_2 + 8.32\ N_2.$$

The air fuel ratio is 10.516 ÷ 1 and the excess air is 10 per cent.

The equations for combustion with excess fuel, when methane is burned with a deficiency of 5 per cent of air, are:[2]

$$CH_4 + 0.95 \times O_2 + 0.95 \times 2 \times 3.78\ N_2 = ZCO_2 + (X - Z)\ CO + 2H_2O + 7.182N_2.$$

In this expression X corresponds to the subscript for C in CH_4. The value of Z may be determined as follows:

$0.95 \times 2 = 1.9$ volumes of O_2 are supplied.

The O_2 remaining after the hydrogen has burned is: $1.9\ O_2 - 1\ O_2 = 0.9\ O_2$.

This will be divided between CO_2 and CO as follows:

$0.9\ O_2 = ZO_2 + \frac{1}{2}\ (X - Z)\ O_2$. Since $(X - Z)\ O = \frac{1}{2}\ (X - Z)\ O_2$.

But for CH_4, X = 1, hence

$0.9\ O_2 = ZO_2 + (1 - Z)\ O_2$ or

$0.9 = Z + \frac{1}{2}\ (1 - Z)$ Solving

$Z = 0.8$

$1 - Z = 0.2$.

[2] See article by Professor Joseph Liston. "Combustion Phenomena in the Natural Gas Engine," February, 1936, Refiner.

Substituting these values in the above equation:

$CH_4 + 1.9\ O_2 + 7.182\ N_2 = 0.8\ CO_2 + 0.2\ CO + 2H_2O + 7.182\ N_2$.

The air fuel ratio is 9.08/1.

The theoretical composition of the products of combustion are:

CO_2, 9.77; CO, 2.44 and N_2 87.79 per cent respectively.

The deficiency of air is 9.56 — 9.082 ÷ 9.56 = 5 per cent.

These equations for incomplete combustion are based on the assumption that the hydrogen in the gas will be burned to water, and that a considerable percentage of carbon monoxide may be formed without a portion of the gas escaping unburned, and, of course, that the composition of the fuel is known. However, the correct theoretical values for the constituents of the flue products from a given gas, when tabulated, afford an excellent means of checking up on flue gas calculations.

Table I. Theoretical Flame Temperature of Natural Gas for Varying Percentages of CO_2.

Per Cent CO_2	Flame Temp. °F	Per Cent CO_2	Flame Temp. °F
12	3600	9	3120
11	3450	8	2900
10	3000	7	2600

Gas 80.5 per cent CH_4; 18.2 per cent C_2H_6 and 1.3 per cent N_2.

Table II. Changes in the Percentages of the Volumes of Flue Gas for Varying Percentages of CO_2.

CO_2 from Recorder Per Cent	CO_2 Per Cent	O_2 Per Cent	N_2 Per Cent	Air Excess Per Cent	Air Deficiency of Per Cent
8.0	0.0	6.96	85.04	44.9	0.0
9.0	0.0	5.23	85.77	30.0	0.0
10.0	0.0	3.48	86.52	18.0	0.0
11.0	0.0	1.74	87.26	8.1	0.0
12.0	0.0	0.00	88.00	0.0	0.0
11.0	1.23	0.00	87.77	0.0	0.2
10.0	2.51	0.00	87.49	0.0	0.4
9.0	3.87	0.00	87.13	0.0	0.6
8.0	5.28	0.00	86.72	0.0	0.8

Gas burned 86.0 per cent CH_4; 14.0 per cent C_2H_6.

Table III. Gas Analysis of Resulting from Combustion of a Gaseous Fuel.

% by Volume	Test No. 1	Test No. 2	Test No. 3
CO_2	5.3	8.0	10.5
O_2	0.0	5.4	2.5
CO	9.6	0.8	0.0
H_2	4.8	1.0	0.0
CH_4	3.5	0.8	0.6
C_nH_{2n}	0.3	1.0	0.0
N_2	76.5	83.0	86.4

Table IV. Theoretical Maximum CO_2 for Gaseous Fuels

Natural Gas	11.8 per cent
Coke Oven Gas	11.0 per cent
Retort Coal Gas	11.2 per cent
Carburetted Water Gas	17.2 per cent
Blue Water Gas	22.3 per cent
Theoretical Water Gas	20.9 per cent
Anthracite Prod' Gas	19.5 per cent
Bituminous Prod' Gas	19.0 per cent
Blast Furnace Gas	23.9 per cent

Table I is from a graph prepared for the gas used in the City of Cleveland, Ohio. The flame temperature of this gas is 38 deg. lower than that of the gas discussed. The temperatures of both gases being corrected for dissociation.

Table II is designed to aid in interpreting the readings of the CO_2 recorder, when the gas is of the composition indicated. Mr. Darnell finds the CO values in this table slightly in error when reported to the second decimal place. It was not revised.

Table III, from the November, 1936, issue of "Gas" is reproduced here to show some of the vagaries of the combustion process. This table was prepared by William A. Bone, of the Imperial College of Science and Technology, London, England, who found that hydrogen could be present in considerable quantities in the presence of oxygen and with or without carbon monoxide.

Table IV, abridged from a table prepared by the American Gas Association, is given to show that there are at least four other gaseous fuels, beside blast furnace gas which have CO_2 values above 14 per cent.

Figure 1 shows the diagrammatic arrangement of a combustion control system designed for gas fuel, and using the CO_2 as an index of the fuel-air ratio. The manufacturers description of the method of adjusting the CO_2 follows:

"To increase the CO_2, the size of orifice 4 is decreased. This restricts the flow of gas from the downstream side of the gas valve on the gas tube. Hence, for a given draft, orifice 1 will be closed by diaphragm 16 because gas is flowing out of orifice 3 faster than it is flowing into the furnace side of diaphragm through orifice 4. This allows the fuel regulating valve to open a little wider with a given furnace draft and gives a higher CO_2. To decrease the CO_2 the size of orifice 4 is increased."

We agree with Mr. Darnell that a mechanically operated air flow meter would be more reliable and of greater assistance to the boiler operator than a manually operated CO_2 recorder.

WITH the advent of low cost electric power, many non-metallic minerals not commonly used will justify attention by industry, according to Bureau of Mines authorities. The bleaching of clay by electrodialysis justifies considerable investigation, as this method has been shown in the laboratory to be an effective way of obtaining good quality clay. The most important cost is the power requirement.

Readers' Conference

Then and Now

IN THE ARTICLE entitled "Then and Now" by C. W. Peters, published in your August issue, the author bases his calculations relating to excess air and fuel loss upon the assumption that perfect combustion will give 20.7 per cent CO_2.

This would be quite correct if the fuel were pure carbon, but as it appears from the context, that the figures under discussion are those obtained with the fuel actually burned, which was evidently not pure carbon, but some class of commercial coal, it is misleading to base the calculations upon the assumption that perfect combustion without excess air, will give 20.7 per cent CO_2.

Of course the percentage of CO_2 which represents perfect combustion, depends upon the analysis of the fuel which we are actually using, but it will be found to be approximately as follows.

Pure carbon	20.7% CO_2
Fuel oil	15% CO_2
Bituminous Coal	17.9 to 19% CO_2
Anthracite Coal	19.3 to 19.9% CO_2
Natural gas	11.9% CO_2.

In this connection, it may be of interest to note that the cubic feet of free air at about 65 deg. F. required for perfect combustion of any fuel, will be almost exactly one per cent of the B.t.u. content of the fuel, to which, of course, excess air must be added.

Bloomfield, N. J. JAMES O. G. GIBBONS.

IN THE AUGUST 1937 issue of Power Plant Engineering, page 501, C. W. Peters gives some interesting facts about combustion conditions in power plants under the caption "Then and Now". But it appears he has not correctly figured the saving which he effected by plugging up leaks in the setting and thereby increasing the CO_2 content of the flue gas from 6 per cent to 14 per cent.

The kind of coal burned was not stated but even if we consider anthracite, the maximum theoretical CO_2 probably was not more than 20 per cent. Assuming this value, the excess air for any CO_2 value may be calculated by the formula:

$$E = \frac{(CO_2 \text{ max.} - \text{actual } CO_2)\ 0.791}{\text{actual } CO_2\ (100 - CO_2 \text{ max.})}$$

When burning anthracite having a maximum theoretical CO_2 of 20.0 per cent, if the actual CO_2 is only 6.0 per cent the excess air is 230 per cent. If the CO_2 value is increased to 14.0 per cent by stopping up leaks in the setting the excess air will be reduced to a value of 42.3 per cent. But the fuel saving cannot be measured directly in terms of the difference in the percentages of excess air. It is well known to combustion engineers that for approximately the same range of capacities, a higher CO_2 value which produces a higher furnace temperature will give a lower exit gas temperature than a lower CO_2 value which produces a lower furnace temperature but a higher exit gas temperature.

In the case cited by Mr. Peters, he does not state the exit gas temperature for the two CO_2 values but it is quite likely that if he had 550 deg. F. for the 6 per cent CO_2, when the leaks were stopped and the CO_2 increased to 14 per cent, there was an increase in the boiler output but the exit temperature may have increased somewhat since the increased CO_2 was not due to changes in firing conditions which would give higher combustion temperature.

Heat loss in the chimney gases must be calculated from values of the weight of gas and the temperature above the combustion air. Usually the weight of dry gas is first calculated and then the heat loss for this weight of dry gas determined. To this is added the loss due to the water vapor in this gas. Besides the CO_2 content of the flue gas, the O_2 value must be known or calculated.

In the case of anthracite with a maximum theoretical CO_2 value of 20 per cent, the actual oxygen value of the chimney gases, corresponding to the CO_2 value may be calculated as follows:

$$O_2 = \frac{20.9\ (CO_2 \text{ max.} - \text{actual } CO_2)}{CO_2 \text{ max.}}$$

For 6 per cent CO_2 the oxygen value will be 14.6 per cent and for 14 per cent CO_2 it will be 6.3 per cent.

The weight of dry gas is calculated as follows:

$$W = \frac{4CO_2 + O_2 + 700}{3(CO_2 + CO)}\ (C\text{-}C_r)$$

where,

W = pounds of dry gas per lb. fuel
C = per cent ultimate carbon in fuel
C_r = per cent carbon in the ash pit, calculated as per cent of 1 lb. of fuel.

A representative ultimate analysis of anthracite, as fired, may be considered as follows:

Carbon	70.2	per cent
Hydrogen	1.9	" "
Oxygen	6.8	" "
Nitrogen	0.2	" "
Sulphur	0.9	" "
Ash	20.0	" "
	100.0	" "
B.t.u. 11,650		
Moisture	4.6	" "

DRY GAS LOSS FOR 6 PER CENT CO_2

Calculating the dry gas loss for 6 per cent CO_2 and assuming 25 per cent carbon in the ash pit, we find:

$$W = \frac{24 + 14.6 + 700}{18} \times (0.702 - 0.0668)$$

W = 26 lb. dry gas per lb. fuel.

B.t.u. dry gas loss per lb. fuel $= 26 \times 0.25 \times (550\text{-}70)$
$= 3120$ B.t.u.

$$\text{Per cent dry gas loss} = \frac{100 \times 3120}{11{,}650} = 26.75$$

Water Vapor Loss

B.t.u. lost in water vapor =
$9H\ [212 - t + 970.4 + 0.46\ (T - 212)]$
where,

H = Per cent ultimate hydrogen in fuel
t = temperature of combustion air, deg. F.
T = temperature of flue gas, deg. F.

For 6 per cent CO_2 and flue gas temperature of 550 deg. F., the loss due to water vapor in the flue gas will be:

B.t.u. loss =
$0.178\ [212 - 70 + 970.4 + 0.46\ (550 - 112)]$
$= 226$

$$\text{Per cent loss} = \frac{100 \times 216}{11{,}650} = 1.94$$

Total chimney loss for 6 per cent $CO_2 = 26.75 + 1.94 = 28.7$ per cent.

Dry Gas Loss for 14 Per Cent CO_2

Assuming there has been no change in firing conditions and that the higher CO_2 value is due solely to stopping up leaks in the setting, there will, of course, be no change in the temperature of combustion and the absence of leakage may cause a slight rise in the exit temperature of the gases.

$$W = \frac{56 + 6.3 + 700}{42} \times (0.702 - 0.0668)$$

W = 11.5 lb. dry gas per lb. fuel.

B.t.u. dry gas loss per lb. fuel =
$11.5 \times 0.25 \times (550 - 70)$
$= 1380$ B.t.u.

$$\text{Per cent dry gas loss} = \frac{100 \times 1380}{11{,}650} = 11.85$$

Since the change in CO_2 will not affect the water vapor loss this item will be the same.

Total chimney loss for 14 per cent $CO_2 = 11.85 + 1.94 = 13.8$ per cent.

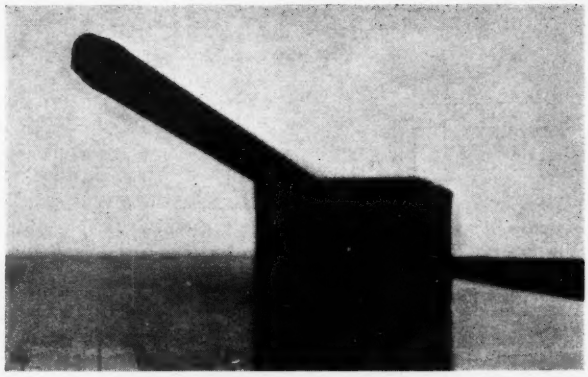
The difference between 28.7 per cent and 13.8 per cent is 14.9 per cent which is equivalent to a saving of $14.9 \div 28.7$ or 51.8 per cent. In other words there was a saving of more than half the coal pile.

Details of calculations for various items of loss necessary for a heat balance, for various representative fuels may be found in my article under the caption "Flue Gas Weights Calculated From Fuel Analyses" pp. 394-397, July 1936.

Chicago, Ill. J. R. Darnell.

Gage Glass Wears Out

The water column gage glass illustrated here was taken from a fire box boiler in Detroit, Mich. The 125-hp., 125 lb. boiler was not in a basement but in a hole just large enough for it, and with just space enough between the ceiling and the boiler for a man to crawl over the top. This glass was not quite 4 ft. from the ceiling and a man would get a fine shower bath of hot water, when shutting off the column. The owner objected to getting a new one as he said it had been in a long time and thought it ought to last awhile yet. I told him it had been in long enough. I took it out the following Sunday and had new cocks to put in the column and attached a chain to close it off in case of an accident. The valves were so corroded that the stem broke while I was trying to close it.



Steam eroded gage glass

The end of the glass which was eaten away is the steam end, caused by steam leaking past the rubber gasket. It was certainly a fine glass, proved by the fact that every time ash was removed the cold air blew right on it and it was winter when the writer removed it.

Chicago, Ill. Hugh H. Welbon.

The Psychology of Advancement

Mr. Hafford, in June Conference, raises a very pertinent point. He refers to managements' practice of going afield for their better paid help and neglecting home talent. This custom must be very widespread because I have come across numerous cases in the East while Mr. Hafford appears to have seen the same thing in his territory. It is a strange and, to my way of thinking, peculiarly inefficient way of operating either a power plant or manufacturing establishment.

Some time ago I heard of a case in point. A company had erected a brand new power plant costing well over a million dollars. They began to look for operators. The employment manager who, I believe, is a very reputable man, a noted writer on efficiency subjects, got together a staff.

With quite a large and expensive property investment to care for, one would have imagined that he would have tried to get good practical men who would take a great interest in the plant and endeavor to make a permanent connection. But no, he acted on the "playing fields of Eton, old school tie" philosophy and almost filled his list with college men like himself. This, may I remind readers, was his choice for operating berths in a new power plant where, as anyone knows, there will be many small engineering adjustments to take care of in the initial year or so. What happened is easy to fathom. The salaries paid were quite fair for practical operating engineers but certainly not enough to repay the investment involved in a college education, even though a minor college. The college men, quite

good fellows though they were, looked upon the position as an expedient, were unfitted through lack of practical training to do even the simplest adjustment and, at the first opportunity, got out.

Efficient though they were to show, theoretically, how a job should be done, they could not actually do it and these jobs fell to the real engineers who had plenty to do themselves. When last I heard of it, the plant had deteriorated far more than its age would justify and had had a labor turnover quite remarkable for its size. The same hiring practice was still in force, however. Some of the mistakes made by these inexperienced men were ludicrous in the extreme.

Brooklyn, N. Y. TUBAL CAIN.

Oil Passing to Humidifiers Due to Defective Systems

CONSIDERABLE trouble was experienced with cylinder oil flowing to the humidification systems of an indirect heating system with steam jet type humidifiers installed in preheating chambers. The oil separators, grease or oil traps were carefully inspected and overhauled, and adjustment of the lubrication of cylinders of the engines and pumps correctly performed to assist in elimination of oil accumulations to the spaces for air flow. The oil flowing to the humidifiers in an atomized form resulted in an accumulation in preheating chambers of the heating systems.

Various operating performances for manipulation of humidification and drainage system were carefully maintained. All corrective methods failed to prevent the oil formation in the humidifiers and the air chamber surfaces. The cause of oil accumulation was located in the drainage connection of the steam piping system to the humidifiers. The drain pipe was connected to the main drainage system carrying the discharge from the oil or grease traps to the sewerage system. The humidifier equipment that is adjacent to the oil trap location received the largest amount of oil and emulsified material from the exhaust steam systems.

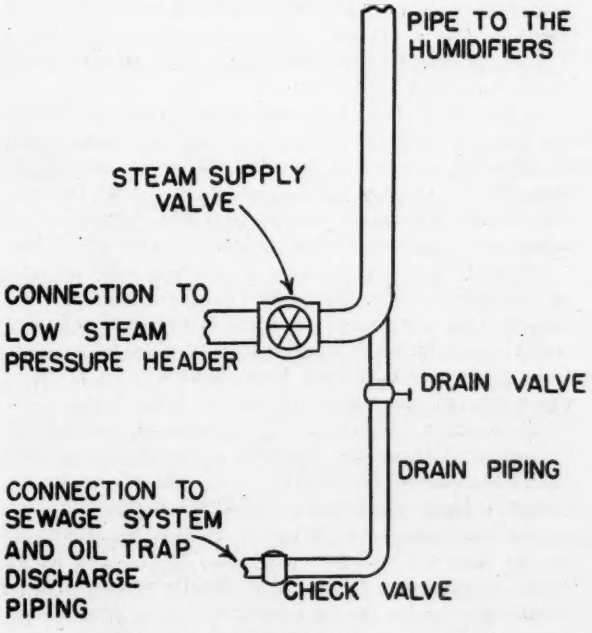
The check valves that were installed to prevent the back flows from discharge of the trap systems to the drainage sections of the humidifiers were in a defective condition, allowing oil flow to the humidification systems during the periods drain valves on the humidifiers were open during the non-service periods of this equipment. The drain valve from the humidification steam piping systems to the main drainage pipes (after discovery of this defective condition) was maintained closed except during initial operation of humidification units for drainage of this equipment.

The drainage systems of the humidifiers on heating systems should be connected to the main condensate pipes for feedwater to boiler units, eliminating the loss of pure water at high temperatures. All connections of drainage from the steam pipes and the humidifier units should be included in the condensate return system with approved check valve installed on drainage system.

Careful designs and operation are necessary in providing correct humidification and in preventing odors in the air which flows to air conditioning systems. Oil, grease, emulsified material and water formations in the air and heating chambers provide unsanitary conditions due to accumulations in inaccessible spaces of air conditioning systems. Proper inspection, observations, and operation are essential for adaptable humidification for occupancy in the educational structures.

The humidifier drainage drip opening or connection should be connected to an open free passage without direct piping and valve installations to the sewage or other drainage system. As the system having pressure for flow of the substance will cause the various substances to pass to and through the humidifier causing contamination of the air volume for the interior spaces, careful planning of the steam jet or the air washer humidification application is necessary to avoid flows to the interior of this equipment during the service and non-service periods of contaminating substances from other servicing equipment.

Chicago, Ill. THOMAS J. BRETT.


PIPE TO THE HUMIDIFIERS
STEAM SUPPLY VALVE
CONNECTION TO LOW STEAM PRESSURE HEADER
DRAIN VALVE
DRAIN PIPING
CONNECTION TO SEWAGE SYSTEM AND OIL TRAP DISCHARGE PIPING
CHECK VALVE

Piping Connection to Humidification System

Valve Position Indicator

I HAVE found the indicator described below to be of great help. It may be helpful to others.

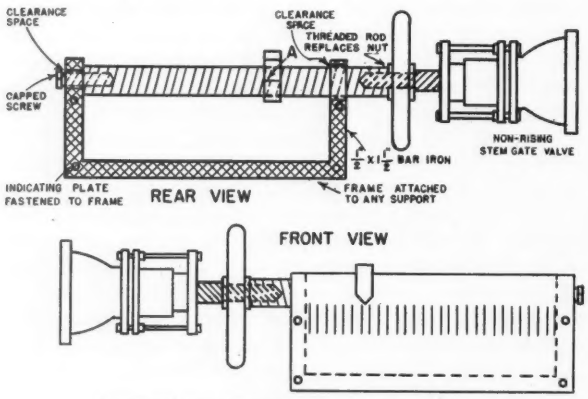
There are times when one or more gate valves must be controlled by hand to admit only a certain amount of water or steam, and in order to tell at a glance how many turns the valve is opened, without closing completely and reopening, an indicator is necessary. The indicator described here is simple, effective and can be made with a minimum of cost and labor.

In the sketch are shown the front and rear views of the indicator. The indicator pointer is made of sheet brass and is brazed to a brass nut which is screwed to the outside screw of gate valve. The face of indicator is also made of sheet brass and is fastened by screws to an iron frame bent as shown by dots.

The iron must be sufficiently wide to have holes large enough so that the valve stem may fit into them easily. The end of the stem is fitted with a nut to keep the indicator from slipping off. The marks on face of indicator are spaced according to the pitch of screws

on valve stem, that is, if the pitch is ¼ in. then the marks are spaced ¼ in. apart.

At "A" is shown the brass nut to which the indicator pointer is attached and you will notice how it slips on the valve stem.



Front and rear views of valve position indicator

When the valve is closed the indicator is set at zero, and when opening, with each revolution of the valve wheel the pointer will move one mark, thereby enabling the engineer to know at a glance how many turns the valve is opened.

Cleveland, Ohio. JAMES A. LICCARDI.

Combustion Instruments

IN POWER PLANT ENGINEERING for April, June and September, 1936, and March 1937, Messrs. Cooney, Swain, and Darnell discuss the combustion of natural gas and the means to be employed for best results. On most points the parties involved have forwarded some sound arguments upon which the innocent by-stander may no doubt reach a final opinion not far from the truth. However, the discussion has now become one regarding the relative merits of two such diverse combustion guides as the CO_2 recorder and the air pen-steam pen type meter. On this point I believe I can add something of value since I have had much experience with both, not only on natural gas but solid and liquid fuels as well. I specifically wish to challenge the statement which Mr. Darnell says is based on his experience that "the boiler meter (air pen-steam pen) is more reliable and greater assistance to the operator than any CO_2 recorder." Now for some facts!

The central station plants have been the big users of the boiler meters, yet the A. S. M. E. Transactions contain an interesting paper where the engineers of one large utility attempted to change and recalibrate the device in an effort to make a check with the CO_2 readings. In a report of the Prime Movers Committee of the N. E. L. A., published by the Edison Electric Institute July 1933, there appears the remarkable statement:

> "Reports were secured of methods used by member companies in operating the boiler plant to prevent a deficiency of air because of concern expressed by several members that steam flow-air flow meters might show correct operation when there was deficiency of air with resulting CO in uptake gases . . . Meter calibrations are checked for correctness by making gas analyses, with an Orsat apparatus. In all cases checks are made at least daily and, in the majority of instances, several times each day."

My own experience has proved this checking and re-checking necessary, especially with gas firing. If we are going to check by gas analyses why not operate by gas analyses directly, and not introduce the complications which the air pen-steam pen meter involves?

In discussions with operators who have steam flow-air flow meters, it is often stated by them that they are actually measuring the air. Of course, they do no such thing! What is really done is to measure a pressure drop across a portion of the gas passage through the boiler setting due to the flow of flue gas. Everything else being equal (which it is not) the drop would obey the law of flow through orifices and vary as the square of the flow. This gas quantity is assumed proportional to the air supplied, and in a rather round-about-way the steam flow is related to the air supplied via the fuel burned. The accuracy of the device is dependent on the steam measurement being an accurate index of the heat output. This means constant feedwater temperature and constant steam quality or specific volume. The latter makes the steam meter read inaccurately and a different quantity of heat added per pound of water fed destroys the relation between steam output and heat output, assumed a constant ratio in the device. The flue gas flow is not directly related to air supplied except where fuel is of constant chemical composition. Any variation will alter the ratio of water vapor to dry gas in the combustion products and alter the drop which the so-called "air pen" records. If the CO_2 recorder is damned because a variation in fuel composition will alter the theoretically perfect combustion condition which corresponds to zero excess air, then the "air pen" must be doubly damned since it is not only affected by varying fuel composition which alters the water ratio in the flue gas, but is also affected by a variation in specific volume of flue gas due to leaky baffles, varied heat absorption due to scale within or soot without the tubes, all of which vary the average temperature in the portion of setting where drop is taken so that it fails to follow the normal variations in flue gas temperatures which are the natural result of altered ratings.

In the CO_2 method the assumption is made that there is a definite relation between CO_2 and excess air; that the best CO_2 and lowest practical excess air may be determined for various conditions of load; that the fuel composition is constant enough to ignore, except for an occasional check; and that a small variation in CO_2 when the CO_2 is high is of no account as a loss requiring correction. The steam flow-air flow method complicates this simple relation by introducing another variable (the steam flow) and with it a host of assumptions, some of which have been mentioned, and all of which are not entirely consistent with the facts.

There are a number of CO_2 recorders on the market and many of them are regarded by operators as poor guides because of certain errors or lags which are inherent in their construction or which result from improper maintenance. Since it is the concensus of opinion that all combustion devices be checked by an Orsat, I have come to feel more kindly toward a type which operates as nearly like an Orsat as possible.

Jackson, Miss. J. A. ROULTON.

Light on the Lighting Circuit Problem

THE LIGHTING circuit problem submitted by G. E. G. on page 728 of the December issue brought forth many interesting schemes from various readers, although none of them comply absolutely with all the requirements set forth by G. E. G. For the benefit of G. E. G. and others who may be interested in the problem, we are presenting several of the more interesting schemes here:

G. E. G. does not show the lamp switch connections, but I presume that they are in accordance with the usual standard, as shown in Fig. 1, and that the single pole master switch will be installed approximately as indicated.

It is obvious that if all the lamp switches are set in the "On" position, all six of the lamps will be under the control of the master switch, but as G. E. G. says that he wants the master switch to control regardless of the position of the local switches, I presume that he

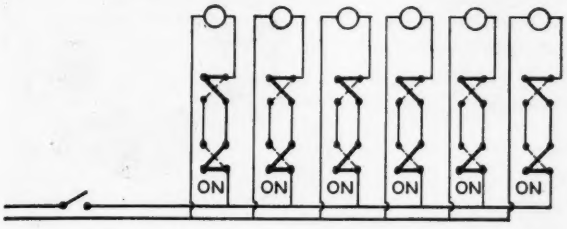


FIG-1

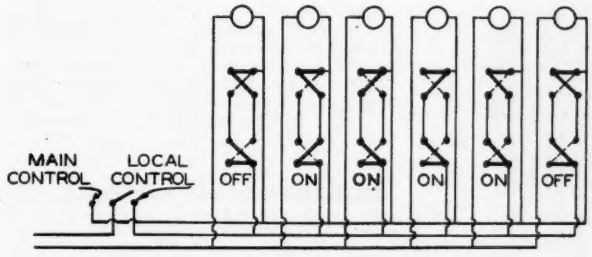


FIG-2

Fig. 1. Circuit with single throw master switch
Fig. 2. Control with double throw switch

wants both methods of control to remain available at all times, otherwise, of course, he could lock the local switches in position by removing the push buttons or keys, or he might put permanent jumpers across the switch contacts.

I do not think that both methods of control can be obtained with a single throw switch, but if a double throw switch is installed it can be connected as shown diagrammatically in Fig. 2, which provides for two methods of control, depending upon the position of the master switch. JAMES O. G. GIBBONS.

REFERRING to the lighting circuit problem in the December number, the accompanying sketch, Fig. 3, using one 3-point switch instead of two, shows how the problem might be solved. In switching off the lights by means of any of the switches, the blades shown in full are fully controlled by the master switch; no lights can be cut off with the blade in this position if the master switch is on. With the master switch out all three point switches act as single pole switches.

Queens, L. I., N. Y. WM. HESS.

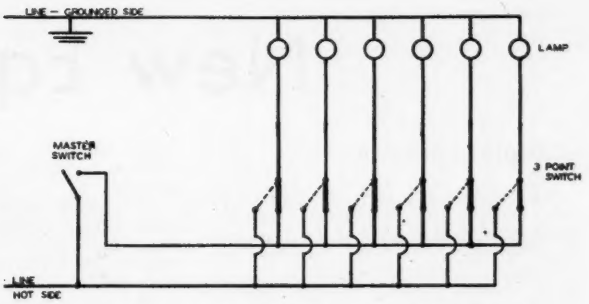


Fig. 3. Control with three point switches

GUSTAVE STEEGE, instructor in the wiring department at the Coyne Electrical and Radio School, Chicago, submits Fig. 4 with the comment:

You will note that for this type of control, 3 and 4 way switches must be used in place of 2 and 3 way switches."

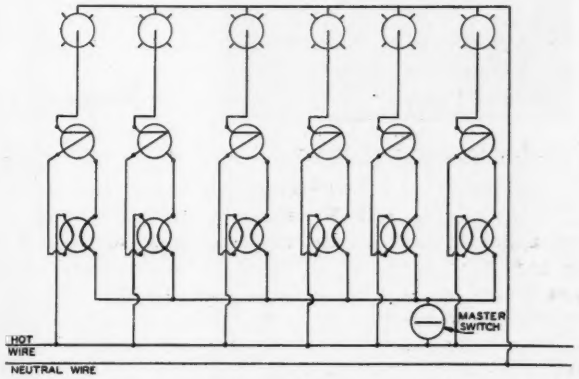


Fig. 4. Use of three and four way switches

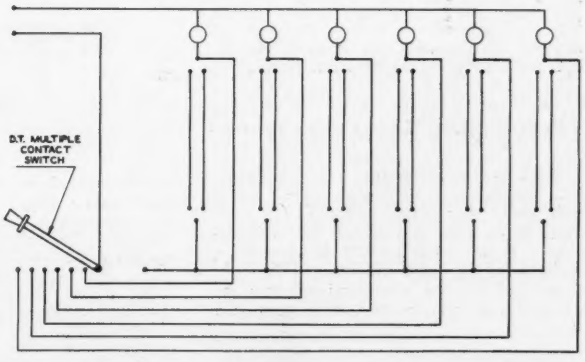


Fig. 5. Solution not in accordance with requirements

This same solution was also suggested by W. O. Beck of the W. O. Beck Electric Service Co., Toledo, Ohio.

AN ANONYMOUS reader submitted the diagram in Fig. 5, a rather "far fetched" solution and not in accordance with the requirements, but we present it just for the sake of interest.

New Equipment

Multiple Spreader

EMBODYING a new principle in overfeed coal firing, the Fyr-Feeder multiple pneumatic spreader stoker of the American Coal Burner Co., 155 E. Superior St., Chicago, Ill., consists essentially of a hopper feeding a group of screws spaced across the front of the boiler setting on 11 in. centers. A ratchet and dog mechanism on the end of each screw, so designed that the degree of turn can be varied, drives each screw from a reciprocating link which in turn is driven by a fractional horsepower motor through a gear reducer.

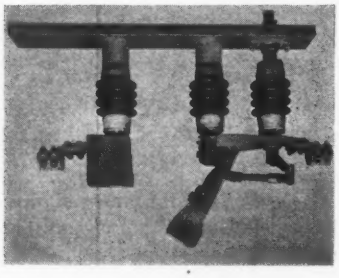
Coal is fed by the screws to a 45 deg. incline and rolls to a "blast" shelf, located about 20 in. above the grate level. At this point, a blast of air, set in motion by a small steam jet, strikes the descending coal, distributing it over the forced draft grate area, according to size, the larger pieces of coal falling at the front and the smaller sizes progressively toward the rear. The dust is burned in suspension, much the same as in pulverized coal practice; thus the air used for distributing the coal performs a double function in that it also aids combustion.

Operation of the stoker is such that only a three to five minute supply of coal is on the grate at any one time, thus eliminating banking losses. Flexibility to answer varying load demands is readily available, as any of the screws can be put out of operation or the rate of feed varied.

Heavy Duty Switches

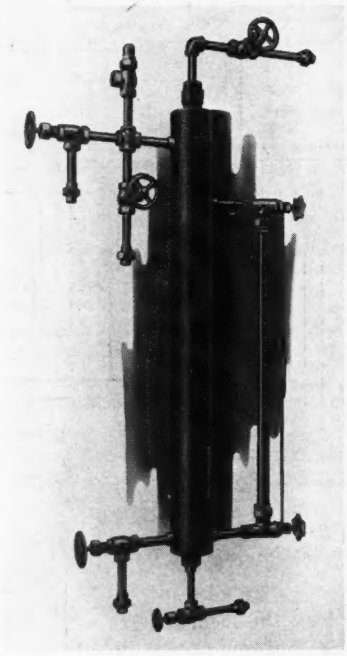
DELTA-STAR ELECTRIC Co., Chicago, Ill., has recently developed a new single pole unit of a three pole 15 kv. 1,200 amp. three pole manual or motor operated Type "FMB-139" disconnecting switch for inverted mounting. The two fixed and the one rotating insulators are of the post construction with flashover values of 85 kv. dry, 50 kv. wet. The rotating insulator is equipped with ball bearings.

The blade first rises to a parallel position then changes to a lateral movement and enters the fixed full floating contact. With this parallelogram arrangement the switch operates without subjecting the insulator parts to shocks or jars.



Purgers for Ammonia and Freon

PURGERS for ammonia or Freon refrigerating systems are offered in a new line developed by Frick Co., Waynesboro, Pa. Purgers operate on the principle that refrigerant mixed with air and other undesirable gases will be condensed to a liquid by a cooling coil inside the drum

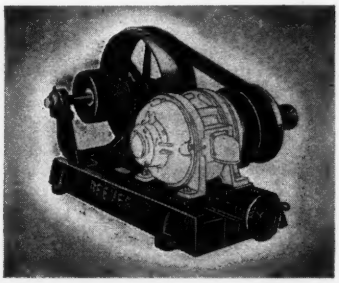


and separated in this manner from the gases to be blown off. The new purger is adequately adapted to Freon systems and it is said that proper purging frequently reduces the head pressure as much as 25 lb. gage, even though the plant might have been thoroughly pumped out before it was charged.

Reeves Vari-Speed Motor Pulley

THE VARI-SPEED motor pulley recently developed and improved by the Reeves Pulley Co., Columbus, Ind., is a simple, compact variable speed unit which is mounted on the standard shaft extension of any constant speed motor. It forms direct drive from motor to driven machine in capacities up to 7½ hp. Through handwheel control, a sliding base on which the motor and unit are mounted is moved forward or back, varying the diameters of a set of adjustable discs from which a V-belt runs to the driven machine. Desired speed changes are made as the belt runs from maximum to minimum disc diameters.

For requirements of either unusual speed reduction or speed increase, a countershaft is mounted on a common base with the rest of the unit. In the former design of this unit, the pulley on the countershaft from which power take-off was made to the driven machine, was mounted on the end of the shaft.



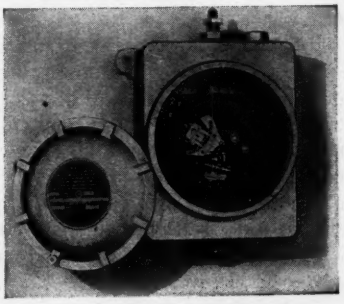
In the new design, illustrated, this pulley may be mounted in the center of the countershaft, between the two bearing housings, thus providing a much more compact, space-saving unit in installations where this factor is important.

While a straight-face pulley is illustrated, power take-off may also be from sprocket, pinion, multiple V-belt, sheave or any other accepted drive.

Explosion Proof Cases for Mercoid Controls

EXPLOSION PROOF automatic controls have been developed by The Mercoid Corp., 4213 Belmont Avenue, Chicago, Ill., explosion proof cases being shipped as complete assembled units, ready for installation.

Consisting of a glass tube containing sealed contacts of special material and a quantity of mercury to make or break the circuit when the tube is tilted, the Mercoid switch used in these automatic controls has no open arcing, oxidation or corrosion, but for places so hazardous that double protection against explosion is essential, the new explosion proof cases are utilized, since unless the automatic



controls are enclosed in explosion proof cases, the complete installation of electrical equipment is not explosion proof.

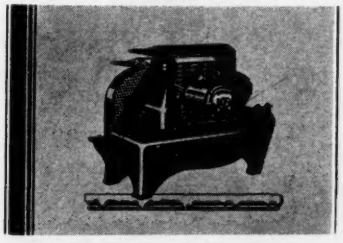
These encased controls are produced for pressure controls ranging from 0 to 2500 lb., for use with air, oil, water, steam, ammonia or other chemicals not injurious to brass or steel; and for temperature controls from minus 30 deg. to plus 450 deg. F. Transformer relays and lever arm and float operating controls can also be encased to provide complete safety.

Lever arm controls for mechanically opening and closing electric circuits can be furnished, explosion proof, in three types: Snap Action, Direct Action and Three Position Type. The snap action type is best suited for all general applications. The Mercoid switch is locked in position by a snap action mechanism, until the lever arm is raised or lowered to a definite point. Operation is not affected by vibration. The direct action type is used where only a small amount of power is available for actuating the control or where the movement of the lever is limited. The three-position type is direct acting also, except that it operates two switches (independently) to open and close circuits at different positions on the lever arm. The position of each switch is adjustable with relation to the arm.

Explosion proof, encased Mercoid transformer relays with sealed mercury contacts and low voltage pilot circuit to meet the conditions of frequently operating automatic equipment, operate as a low voltage transformer, also as a repulsion relay, hence no other transformer is required.

Refrigerating Units

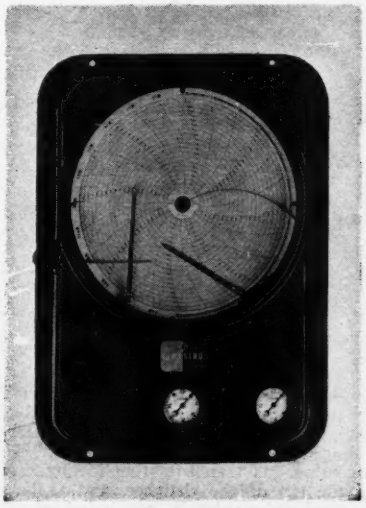
FRICK Co., Waynesboro, Pa., is offering a new line of low pressure refrigerating units for commercial service. They are furnished in 50 types and sizes with motors ranging from ¼ hp. up. Each unit is complete with compressor, electric motor, starter, V-belt drive, condenser, receiver, traps, valves and pressurestat, all mounted on a substantial cast iron base. They are



charged with either methyl chloride or Freon before being shipped. The smallest machine is air cooled; intermediate sizes have condensers arranged for either water or air cooling and the larger units are water cooled. Standard units are also available with gasoline engine drive.

Round-Chart Potentiometer Pyrometer Controller

A NEW ROUND-CHART PYOMETER controller has been developed by The Bristol Company, Waterbury, Conn., known as Bristol's Pyromaster Controller. This instrument is a potentiometer pyrometer, operating on a simplified principle and is available in both pneumatic and electric types. It uses standard thermocouples and extension leads, and is for direct inkmarking on a round 12-in. chart, or for indicating on a large scale.

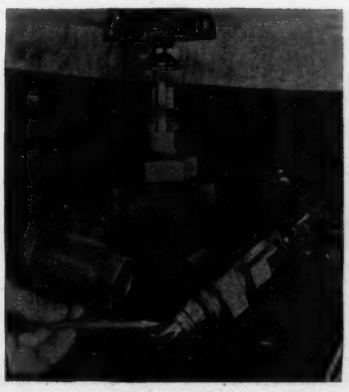


These controllers, it is claimed, require no lubrication; are not affected by plant vibration; there is no mechanical motion of any kind, except when a change in the measured temperature takes place. The simplicity of the operating principle used makes it possible to place the entire mechanism in a standard Bristol's instrument case.

These potentiometer pyrometer controllers are automatically self-balancing and self-compensating for cold-end temperature changes. The pen arm or indicator is actuated in small steps that follow each other at a rate depending upon the rate of change in the temperature at the thermocouple. All lag is thus eliminated, permitting immediate response to changes exactly as they occur.

Hancock Flocontrol Valve

THE HANCOCK VALVE DIVISION of Manning, Maxwell & Moore, Inc., Bridgeport, Conn., has completely redesigned its line of Hancock Bronze Flocontrol valves. These valves are a combination flow instrument and shutoff valve.

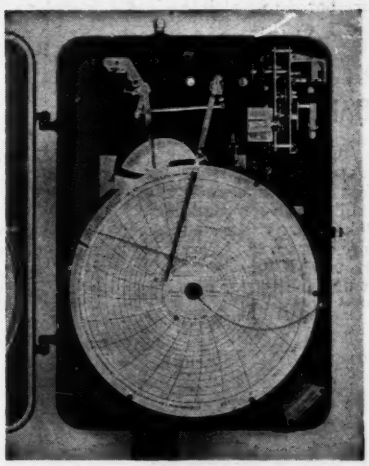


This new line retains the basic proportional flow or straight-line flow characteristic of the original valve. Superhard stainless steel valve seats and discs of 500 Brinell hardness have been so successful in other Hancock valves that the Flocontrol line now also possesses this added wear-resisting feature. This line of valves of this design have an entirely new body of the union bonnet type instead of the inside screw bonnet originally used.

Flocontrol valves are widely used throughout industrial and utility power plants for maintaining closer manual control on oil burner lines, on water treating systems and on cooling water lines to turbines and air compressors. They are perhaps most generally used for continuous blow-down.

Flow Integrator

THE NEW ELECTRIC integrator developed by The Bristol Co., Waterbury, Conn., totalizes flow once every 15 sec. Bristol's Mechanical and Electric Flow meters, for measuring the flow of a gas or nonviscous liquid through a closed line, are now equipped with this type of integrator.

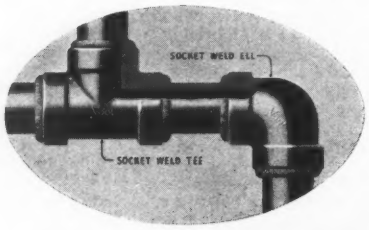


A flat disc cam, shown in the figure partially concealed by the chart plate of the instrument, is specially designed to coincide with the flow law, so that it mechanically computes the square root of the differential pressure across an orifice plate or venturi tube constriction in a pipe line, at 15-sec. intervals. The values obtained are totalized by means of a counter and are indicated on a six-figure integrator dial.

In the illustration the integrating mechanism is shown to the upper right of the cam. It consists essentially of a continuously running telechron motor, which operates a counter through a train of gears. These are engaged and disengaged by means of a mercury switch and magnet. The cam rider, which is connected through a link to the recorder pen arm, operates the mercury switch in one direction while on the cam and allows it to return to its original position when off the cam. In the latter position the magnet is energized so that the gears are meshed and the integrator is totalizing the computations of flow. Thus, while the telechron motor runs continuously, it operates the totalizer counter only when the gears through the integrator are meshed.

Vogt Weld Fittings

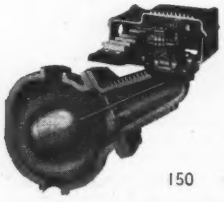
DROP FORGED steel socket weld fittings have been added by The Henry Vogt Machine Co. of Louisville, Ky. to its line of drop forged steel valves and fittings. These weld fittings are provided with socket ends to receive the pipe, thereby



making certain proper alinement before and after welding. No weld "icicles" can clog the pipe or fitting because of the socket construction. Similarity of materials in fittings and pipe make it easy to obtain sound welds. Whether standard, extra strong or double extra strong pipe is used, a smooth passage through pipe and fittings is assured since the fittings are bored to match the inside diameter of the pipe.

Boiler Control Unit

COMBINATION PUMP CONTROL and low water cut-off, in one boiler control unit, has been announced by McDonnell & Miller, Wrigley Building, Chicago, Illinois. The unit is designed for use with steam pressures up to 150 lb. These two controls have distinctly separate operating levels, with the differential between the two

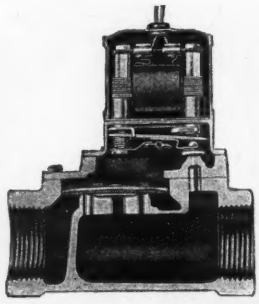


circuits adjustable; also the differential between the off and on operation of the controls is adjustable. A flexible metallic bellows gives dependable transmission of float power to the outside switch mechanism, without the use of stuffing boxes. The pump control circuit is designed to turn on and off an electrically-driven boiler feed pump in accordance with the requirements of the boiler. At a lower level, a second separate circuit will shut off the oil burner or stoker in case of a fuse failure in the pump circuit.

Magnetic Gas Valve

AFTER MANY YEARS of actual test in the field, Julien P. Friez & Sons, Inc., offers a new Magnetic Gas Valve suitable for every type of domestic or industrial use. Provision has been made for the removal of the entire electrical mechanism and moving parts without the removal of the valve from the pipe line.

The illustration shows a standard valve in the closed position. In the closed position the incoming gas leaks through the clearance around the circumference of the disc filling the upper chamber with gas at line pressure. As the gas cannot escape through the bleeder the pressure holds the disc firmly on its seat.



When the control instrument through the electromagnet, lifts the bleeder valve, the pressure above the disc is immediately released to the down stream side. The incoming gas then lifts the floating disc to the top of the chamber, and as long as the bleeder valve is open it is held up.

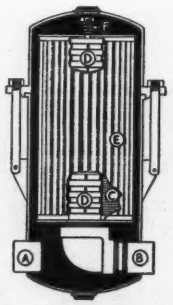
The valves operate on 6 V., A.C. from either 110 or 220 V. supply through suitable transformers especially designed for use with these valves. The electrical current consumption is 6 watts.

Liquid Line Filter

MODEL CPHL, a new Protectomotor liquid line filter for the economical and efficient filtration of lubricating oil to Diesel and other internal combustion engines, is announced by the Staynew Filter Corp., Rochester, N. Y. Constructed along the lines of the Protectomotor compressed air line filter, it employs the same principle of radial fin construction.

Most of these new oil filters are for horizontal lines. In these horizontal line models a drain plug in the bottom half of the filter shell can be removed for draining. They may be opened quickly for inspection or cleaning. This is done either by loosening the fasteners in the case of swing-bolt models or by unscrewing the locking lugs on the bolted models.

Cleaning is a simple matter. It is only necessary to remove the filter insert, dip it in gasoline and scrub with a soft brush.



The cut-away outline drawing illustrates the construction of a unit for high pressure use; A and B are inlet and outlet respectively in standard pipe sizes; C is the wire mesh frame of the radial fin construction; D is the re-inforced core; E is the filter insert and F is the retaining spring. The low pressure model is of essentially the same construction but without re-inforced core or retaining spring. Sizes and models are made for almost unlimited capacities and pressures. This model will accommodate 125 lb. pressure.

Williams' New Hex-Box Wrenches

DESIGNED for severe service, the new heavy pattern wrenches, announced by J. H. Williams & Co., 75 Spring St., New York, provide extra strength and full bearing, the heads are approximately the same thickness as the nuts they serve.

Their comparatively thin head walls are particularly efficient in close quarters. They are drop-forged in 2 lines, carbon steel wrenches and chrome-molybdenum Superrenches, with openings ranging from 1¼ to 3⅛ in.

Coolant Pump

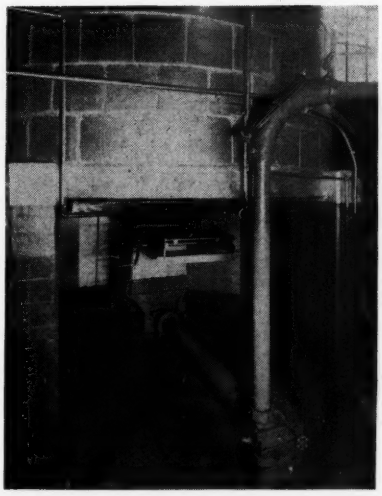
THE NEW Coolant pump of Goulds Pumps, Inc., Seneca Falls, N. Y., is a small, compact, vertical, submerged type centrifugal pump, occupying but little installation space. It is built only in the ¾ in. size and is designed especially for the circulation of coolant, cutting compounds, or similar liquids containing abrasives

in suspension. The impeller is mounted directly on a large diameter extended motor shaft, eliminating necessity of any lower pump bearing. Pump casing is cast integral with motor support, at top of which motor is held in position with male and female lock to insure permanent alignment. Impeller is of open, double-suction type, hydraulically balanced. The motor is ¼ hp., 1750 r.p.m. and capacities range up to 30 g.p.m. and heads up to 19 feet.

THIN-WALLED stainless steel tubing has been developed, of light weight and high rigidity. Narrow strips are helically wound and lock-seamed to form a continuous tube with walls 0.012 in. thick, having a nearly smooth interior and suitable for linings of flues or other uses where non-corrosion is desirable.

Bunker Feeding

DELIVERING COAL directly from bunker to the boiler furnace is a feature now incorporated in the latest designs of pneumatic spread stokers manufactured by the Iron Fireman Mfg. Co., 3266 W. 106th St., Cleveland, O. This is accomplished



by the use of high velocity air from a radial vane fan to convey the coal. The stoker can be located to suit conditions, usually from 8 to 15 ft. from the boiler front or even in a separate room. The illustration here shows the coal feed section installed under a 90-ton coal silo in a boiler room.

New Plants for Keasbey & Mattison

KEASBEY & MATTISON Co., Ambler, Pa., by entry into the asbestos-cement pressure pipe field, has added another line to its extensive list of products.

A new plant, representing an investment of $760,000 is now under construction at Ambler for the sole manufacture of this product. The plant, to be completed the latter part of this year, will begin production early in 1938. Floor area of the new single story plant with service buildings will be 143,000 sq. ft. Roofing and siding will be entirely of asbestos corrugated sheathing which is manufactured by Keasbey & Mattison Co. Over the asbestos corrugated sheathing, which will be the base roof, will be placed a special insulating material, and above this will be a built-up roof. The new plant will have a weekly capacity of 150 tons or approximately 10 miles of asbestos-cement pipe. The pipe will be designed for service at pressures ranging from 50 to 200 lb. per sq. in.

In St. Louis, a second plant devoted to this new production will shortly go into construction. The St. Louis plant will represent an investment of $500,000 for building and equipment and will have a capacity of 100 tons or approximately 7 miles of pipe per week. Production from this plant is also scheduled for early in 1938. Both of the plants will embrace the latest material-handling equipment. Additional employment at these two new plants will number approximately 350 men.

Modern municipal and manufacturing needs have indicated a demand for this type of light-weight, non-corroding, non-tuberculating pipe and, according to officials, have caused this old line company to enter the field for the supply of this product.

Keasbey & Mattison Company now operates two plants at Ambler devoted to the manufacture of asbestos-cement products and a third plant to the manufacture of asbestos-magnesia products, asbestos textiles, etc. They also operate their Ferodo brake lining plant at New Brunswick, N. J.

Illuminated Push-Button Station

AS A FURTHER aid to machine operators, General Electric has developed a new small, standard-duty push-button station with an indicating lamp in the center of the translucent button. Through the combination of the push-button and indicating lamp in a single, compact unit, the new station is proving popular with machinery builders and users alike, because it needs only about one-half the space required by the two devices when they are mounted separately. It is available with buttons in six colors: white, green, blue, red, clear, and amber.

The indicating lamp is operated through a small control transformer which, because of its diminutive size, can be mounted readily in or on a machine. An idea of the compactness of the push-button station can be gained from the fact that it is but two and five-eighths inches high, one and one-quarter inches wide, and two and five-eighths inches thick.

Chicago Power Show

PLANS FOR THE Chicago Exposition of Power and Mechanical Engineering, to be held at the New International Amphitheatre, Chicago, October 4 to 9, have been greatly advanced during recent weeks and the list of exhibitors at this date gives assurance that Chicago will witness an outstanding power show.

Materials and equipment on display will include fuels, combustion units, steam generating and distribution systems, piping and fittings, prime movers, pumps and hydraulic equipment, electric generators and motors, equipment to handle electrical transmission and distribution, control apparatus, instruments of precision, power driven machinery, machine tools, materials handling systems, heating, ventilating and refrigerating machines, air conditioning systems, lubricants, refractories and insulation. Special exhibits will be devoted to the problem of factory cleaning, industrial lighting and the insulation of pipe lines.

Dynamic and interesting displays, many of them in actual factory operation, will characterize the Chicago Exposition. Operating exhibits presided over by the men who have had most experience in product development will enable the visitor to see results quickly and to learn from authoritative sources the scope of their adaptation. Transmission, one of the fundamentals in mechanical engineering practice, will be represented by a large number of working exhibits. Machine tools will also be operated, with indication of their most economical application in relation to all branches of plant engineering. The Chicago Exposition will feature exhibits of Diesel engines and will report the remarkable advance in this form of power generating equipment over a broad industrial front.

The Chicago Exposition of Power and Mechanical Engineering is under the personal direction of Charles F. Roth, President, International Exposition Co., Grand Central Palace, New York.

Frank D. Chase

FRANK DAVID CHASE, since 1913 the president of Frank D. Chase, Inc., engaged in industrial engineering and architecture, died unexpectedly on July 23 at his home in Evanston, Ill. Mr. Chase was the designer of several Chicago office buildings and hospitals, worked in the field of railroads, large industrial plants, newspaper plants and carried on engineering work in several European countries. He was born in Riverside, Ill., received his early education in Evanston Township High School and graduated from the Massachusetts Institute of Technology in 1901. Mr. Chase was a former president of the Western Society of Engineers, a member of the American Society of Civil Engineers, a number of social clubs and last year was president of the Midwest Power Conference.

ANNOUNCEMENT IS MADE by Lewis H. Brown, president of Johns-Manville Corp., that E. S. Crosby has been named president of Johns-Manville International Corp., a subsidiary, succeeding Mr. Brown, and will also be general manager of Asbestos Fibres Distributors and of Replacement Automobile Products department, both divisions of J-M Sales Corp.

Mr. Crosby joined Johns-Manville in 1928, when Celite Co., of which he was vice-president and a director was absorbed, as general manager of the Engineering department and in 1929 he became vice-president and general manager of the newly-formed Johns-Manville International Corp.

News from the Field

LEUPOLD, VOLPEL & Co., 425 N. E. 70th Ave., Portland, Ore., manufacturer of engineering instruments, including long distance water level recorders, has issued No. 1, Vol. 1 of the Hydromike, a house organ devoted to its products.

AT THE NITTANY LION INN, State College, Pa., the Oil and Gas Power annual national meeting was held August 18 to 21, under the joint auspices of the Oil and Gas Power Division and the Central Pennsylvania Section of the A.S.M.E. and the School of Engineering of Pennsylvania State College.

Five sessions were arranged and the following papers prepared for presentation: Progress Reports, by American Locomotive Co., Atlas-Imperial Diesel Engine Co., The Buda Co., Caterpillar Tractor Co., Davenport, Besler Corp., DeLa Vergne Engine Co., General Motors Corp., Ingersoll-Rand Co., Nordberg Mfg. Co. and others; U. S. Navy Contributions to Diesel Engine Development, by E. C. Magdeburger, Bureau of Engineering, U. S. Navy Department; Lubrication Problems in Connection with High-Speed Diesel Engines, by C. G. A. Rosen, Caterpillar Tractor Co.

Correlation of Laboratory Tests on Fuel Oils with Field Operation, by W. F. Joachim, U. S. Naval Experiment Station; Recent Developments in Automotive-Type Diesel Engines, by O. D. Treiber, Hercules Motor Corp.; Diesel-Electric Bus Operation, by Martin Schreiber, Public Service Coordinated Transport Co.; Oil Engine Power Cost Report, by H. C. Major, Chairman, Oil Engine Power Cost Sub-Committee; Sewerage Gas Engines, by W. B. Walraven, Sanitary District, Springfield, Ill.

Waste Heat Recovery from Diesel Engines, by Glenn C. Boyer, Burns & McDonnell Engineering Co.; Penn State Method of Testing Diesel Fuels, by J. S. Chandler, Pennsylvania State College; Oil Flow Through Fuel Nozzles, by Prof. K. J. DeJuhasz, Penn State College; Polyermization of Fuel Oils, by Gustav Egloff, Universal Oil Products Co.

ALLIS-CHALMERS MFG. CO., through its chairman, Otto H. Falk, reports that a new all-time peak in the business of the company has been established during the first half of the present year. Net profits totaling $4,141,748 for the first six months of 1937 are reported against $2,088,600 for the first half of 1936. The company plans new financing to provide additional working capital and the expansion of plant facilities.

HARRY T. PRATT, who for 26 yr. was the chief operating engineer of Campbell Soup Co., Camden, N. J., died at the age of 59 years on Thursday, July 22, 1937. Mr. Pratt was formerly president of the Pennsylvania Chapter No. 1 of the National Association of Power Engineers and was recently district representative of the National Outboard Motor Association and a member of the Institute of Operating Engineers.

W. A. HUNTER, assistant secretary and sales manager of the New York Steam Corp., was transferred on July 1, to the Sales Department, Consolidated Edison, where he became sales manager, wholesale business. Reporting to Mr. Hunter in his new position are the Wholesale Business Bureau, C. W. Meytrott, manager, and the Coke Sales Bureau, R. C. Miller, manager.

AMERICAN-MARSH PUMPS, INC., is the new name adopted by the American Steam Pump Co. of Battle Creek, Mich., since more than 80 per cent of the products of this company are known by the name American-Marsh. These include many types and over 50 per cent of them are not steam operated. There has been no change in the financial structure of the company, no change in management, no change in quality standards maintained for more than 60 yr. and the address is still Battle Creek.

WALTER DOUGAN WOOD, JR., member of the discus squad of the 1936 U. S. Olympic team, and a graduate of Cornell University, 1936, has been appointed to the sales staff of the Philadelphia Office of The Lincoln Electric Co., manufacturers of arc welding equipment, Cleveland, Ohio. Under the supervision of G. R. Johnson, manager of the Philadelphia office, Mr. Wood will work with Messrs. O. P. Lang, H. H. Stahl, R. J. Cogan, W. Sivyer, and P. V. Galambos, in supplying arc welding users in Philadelphia and vicinity with complete welding supply of engineering service on any question or problem regarding the use, or application, of arc welding to their work.

THE AMERICAN ENGINEERING CO. of Philadelphia, has appointed the Sabin Engineering Co., Euclid Sixty-First Building, Cleveland, Ohio, as its representative in that territory for the sale of Lo-Hed Hoists.

INLAND STEEL CO. announces a reduction in price of its 4-way floor plates, effective at once for 3rd and 4th quarter of the year shipments.

DESIGNERS FOR INDUSTRY, INC., of Cleveland, Ohio, has established New York quarters in International Building, Rockefeller Center. A designing staff will be maintained in the New York office which is in charge of H. C. Gooding who was transferred from the Chicago office to become business manager for the Eastern district. John E. Manning will succeed Mr. Gooding as Western Manager with headquarters in the Merchandise Mart, Chicago. George E. Henry, formerly associated with the business paper field, has been appointed sales promotion manager with headquarters in the New York office.

THE HANCOCK VALVE DIVISION of the Consolidated Ashcroft Hancock Co., Bridgeport, Conn., announces the addition of James A. Gibbons to its field sales organization. Mr. Gibbons will specialize on industrial power plant and public utility construction work. He comes to Hancock from The Peabody Engineering Corp. of New York City.

D. D. PENDLETON, for many years associated with Wheeler Condenser and Engineering Co. and Power Specialty Co. now merged into Foster Wheeler Corp., has resigned as their Pittsburgh district manager and has opened an office at 2418 Koppers Building, Pittsburgh, Pennsylvania. Mr. Pendleton is arranging again to act as manufacturers' agent—representing various manufacturers of oil refinery and power plant equipment.

J. H. FISHER, President of the Fisher Governor Co., was honored at a large banquet held recently in the Hotel Tallcorn, Marshalltown, Iowa. This banquet was the concluding event of a three day sales convention attended by 82 Fisher sales representatives from all principal cities in the United States, Canada and Mexico. As a lasting memento of Mr. Fisher's record of 25 yr. of outstanding success as head of the company, each guest was presented with a beautiful privately printed 85-page book containing an interesting history of the company and illustrations of the office and factory, together with portraits of the founder, William Fisher, J. H. Fisher, and outstanding personnel. Notable speakers at the banquet were Governor Nelson G. Kraschel of Iowa and W. A. Sheaffer, President of the W. A. Sheaffer Pen Company.

APPOINTMENT of W. H. Scherer as manager of Worthington Pump and Machinery Corporation's plant at Holyoke, Massachusetts, has recently been announced. Mr. Scherer goes to Worthington after 30 yr. of service with Westinghouse Electric & Manufacturing Co., having been general superintendent of the Westinghouse East Springfield Works for the past 18 yr. At Holyoke, Mr. Scherer will be in charge of the manufacture of equipment recently transferred from the Corporation's plants at Harrison, New Jersey, and Buffalo, New York.

PROMOTIONS AND CHANGES in the personnel of Johns-Manville Corp. are announced as follows: Three new vice-presidents of J-M Products Corp. have been elected.

A. R. Fisher, formerly manager of the Company's largest factory at Manville, N. J., will have charge of the eastern district plants at Asbestos, Que., Nashua, N. H., Manville, N. J., and an insulating board plant to be constructed.

J. P. Kottcamp, who has been manager of the midwestern factory at Waukegan, Ill., will have charge of the central division with plants at Waukegan, Ill., Alexandria and Richmond, Ind., Newell, W. Va., and Marrero, La., his headquarters being at Waukegan.

Alexander Cromwell, manager of Pacific Coast operations, will be in charge of plants at Lompoc, Pittsburg, Redwood City, Los Angeles and Watson, Calif.

Other changes will be: J. E. Begert, who has been head of Cost Reduction department at New York headquarters, will succeed Mr. Fisher as manager of the Manville plant. K. W. Huffine, formerly manager of the Alexandria plant, will become manager at Waukegan, and H. J. O'Brien, who has been superintendent of the Rock Wool department at Manville, will be manager at Alexandria. W. Kelty, who was assistant to Mr. Begert, will become manager of the Cost Reduction department.

Mining operations at Asbestos, Que., and Chrysotile, Ariz., will be consolidated into the Asbestos division in charge of C. H. Shoemaker, vice-president of Canadian Johns-Manville, Ltd.

VOTERS of Cedar Rapids, Iowa, approved 25-yr. franchises for steam and electric service by the Iowa Electric Light & Power Co. at a special election held July 12. The vote was 7,486 in favor of the proposition, and 407 opposed, more than 18 to 1. This was one of the largest votes ever recorded in a special election in Cedar Rapids, and the size of the majority is reported to be the greatest given on a utility franchise question in Iowa for a great many years.

MANUFACTURE of two more of the generators to be used at Boulder Dam is covered in a contract awarded July 27 to the Westinghouse Electric and Manufacturing Co. on its bid of $1,467,000. The two generators, each of 82,500 kv-a. capacity, will complete units A-6 and A-7 in the Arizona wing of the Boulder Dam power house, for which contracts totaling $1,984,634.50, covering turbines, governors, transformers and switches, have been awarded. The contract calls for the manufacture and installation of the first of the new generators in 700 calendar days and the second within 800 calendar days. Two additional generators of the same size to serve the Metropolitan Water District of Southern California are being manufactured and will be installed in units N-5 and N-6 on the Nevada side.

LAMINATED SHIM CO., INC., Long Island City, N. Y., announces the appointment of Owen C. Jones as Assistant to President and in charge of sales promotion. For the past 6 yr. Mr. Jones has been associated with the general publicity department of The Linde Air Products, a unit of Union Carbide and Carbon Corp.

W. W. FENIMORE, sales engineer, has joined the sales force of the Refractory and Insulation Corp., 381 Fourth Ave., New York City, and has opened a sales office in the Philadelphia Bourse Building. Mr. Fenimore was formerly connected with the Syracuse, N. Y., office of the Johns-Manville, Inc.

THE LINCOLN ELECTRIC CO., Cleveland, Ohio, manufacturers of arc welding equipment, announces the opening of a new sales engineering office at 1508 Watervliet Avenue, Dayton, Ohio, in charge of R. P. Sharer. Mr. Sharer attended Case School of Applied Science and later was with the Cleveland Department of Water and the Firestone Tire & Rubber Co. He has taken the training course given by Lincoln to its representatives, hence is prepared to assist arc welding users with their problems.

W. H. NICHOLSON & Co., Wilkes-Barre, Pa., has appointed Bradshaw & Company, 530 Fourth Ave., Pittsburgh, exclusive representatives in the Pittsburgh territory for its lever, foot, solenoid, and motor operated 3 and 4-way valves, in addition to the four types of steam traps made by this company. A. M. Seymour, 29 Hillsboro Road, Rochester, N. Y., has been appointed as represenative in the Rochester-Syracuse territory on the complete line.

CONTRACT for four centrifugal pumps, two 15 m.g.d. and two 35 m.g.d., and eight gas engines ranging from 180 to 800 hp. to operate on sewage gas, has been awarded to the Worthington Pump and Machinery Corp., Harrison, N. J., by the New York City Department of Sanitation. The pumps and engines will be installed at Tallman's Island Sewage Treatment Works. The total contract amounts to $469,000.

WILLIAM R. VAN BOKKELEN has been appointed chief of the Division of Electricity for the 1939 Golden Gate Exposition in San Francisco. He has for 18 yr. been electrical engineer and chief engineer for Coast Counties Gas and Electric Co.

MERGER OF Chelan Electric Co. with Washington Water Power Co. has been approved by Federal Power Commission, stock of the former company being cancelled and all its properties and liabilities being taken over by the Washington Co. Plants involved are at Grangeville and Lewiston, Idaho, and at Chelan, Wash.

J. W. OWENS, Vice-President, The Mercoid Corp., 4201 Belmont Ave., Chicago, Ill., announces the opening of a new office at 1035 Cathedral St., Baltimore, Md., carrying a complete stock of controls, with John Jex, Jr., in charge.

H. B. ALLEN, who for 14 yr. was New York District Sales Manager of The Babcock & Wilcox Tube Co., has resigned from that company to become Vice-President of John B. Astell & Co., Inc., 90 West Broadway, New York, distributor in the New York Metropolitan district of B. & W. boiler tubes and a wide variety of other tubular products including all kinds of welding fittings.

Thomas F. Maher Dies

THOMAS F. MAHER, president and general manager of the Chapman Valve Manufacturing Co., died on August 12, in Providence, R. I., after several months of failing health that ended in cerebral hemorrhage. Mr. Maher was born in Wallington, Conn., 52 yr. ago and began his business career in Hartford. He joined the Chapman Valve Co. in Springfield 28 yr. ago as a minor employee. With only a grammar school education, he bettered himself through night school and extension course training and rose steadily in the Chapman organization until he was widely known in industrial circles as an authority on valves and had attained a broad business acquaintance. His home was in Indian Orchard, Mass. where he leaves his wife, one son and three daughters. John J. Duggan has been appointed to succeed Mr. Maher as President of the Chapman Valve Manufacturing Co.

43 Per Cent Increased Business for Westinghouse

FOR the 6 mo. ended June 30th, the Westinghouse Electric and Mfg. Co. earned a net income of $11,331,772, an increase of 43 per cent over the like period of 1936, during which earnings were $7,937,978.

The net income for the twelve months ending June 30 was $18,493,085, as compared with $13,656,170 for the period ended June 30, 1936, an increase of 35 per cent.

The Board declared a dividend of $1.00 per share on the common stock and on the preferred stock of the Company, payable August 31st to stockholders of record on August 9, 1937. This is the third $1.00 dividend declared so far this year.

Orders booked for the 6 mo. ending June 30th were $142,209,475 as compared with $88,880,060 for the same period in 1936. This is an increase of 60 per cent. For the twelve months ending June 30, 1937, orders were $235,850,719 as compared with $147,525,278 for a like period ending June 30, 1936; also an increase of 60 per cent.

Sales billed for the six months were $101,861,631, corresponding to $77,228,167 for the like period in 1936; an increase of 32 per cent. Billings for the twelve months were $179,102,495 as compared with $137,520,705 for the 1936 period; an increase of 30 per cent.

Unfilled orders at June 30, 1937, were $83,725,878; this representing the high point in unfilled orders since September 1920.

Chain Belt Co. of Milwaukee has just completed the erection of a new building at its West Milwaukee Works to house the machine shop and the West Milwaukee offices. All machine operations except the assembly and manufacture of steel and malleable chains and the finishing of sprocket wheels are being moved from the Milwaukee Works to the West Milwaukee plant. The new building consists of five longitudinal bays and one large transverse bay. The outside dimensions are 152 ft. by 292 ft. The longitudinal bays with the exception of the north and south bays are one story high and equipped with floor operated overhead cranes, while the north and south and transverse bays are two stories high. The transverse bay is equipped with an overhead operated crane for loading and unloading cars on the tracks which also run into this bay. The exterior of the building is finished in red brick with double tier steel casement windows and a saw tooth roof almost entirely of glass. The plant is located on a 52-acre tract and was designed by Eschweiler and Eschweiler, of Milwaukee.

For the Engineer's Library

STEAM PLANT ERRORS. By Frank H. Browning. Third Edition. Size 4¼ by 6 in., 84 pages, paper cover. Published by The Stepler Co., Seattle, Washington, 1937. Price 80 cents.

Those who had an opportunity to see the first edition of this little book when it appeared in 1933 need not be reminded of its excellence now that a third edition has appeared. It is outstanding among books of its kind and nobody reading it can fail to remember the crystal clear logic with which it abounds. As announced on the title page, this book is an appeal to reason, prepared for the practical engineer and fireman and it was written with the sincere hope that it would teach operators who read it to think and think correctly. The author is the engineer examiner for the City of Seattle, and, in this capacity, he has been brought into contact with thousands of practical, and, perhaps, impractical men. The book is the result of Mr. Browning's experience and shows the pattern of thousands of talks, and widely held belief. It analyzes some commonest practices, absurd notions and unnatural impulses in order to discard poor ones, pick out better methods and to gain a clearer mental picture of results.

Written in dialogue style depicting conversations between the examiner and the applicant the elements of safe operation are expounded in a unique and forceful manner. The conversations are breezy, often involving sarcasm in order to impress a fact more forcibly on the applicant's mind. The author employs whatever example or emphasis that suits the purpose and avoids splitting hairs over fine technicalities or the exact similiarity of a homely illustration. This in short is a book for the practical man and one that the practical man will appreciate. It speaks his own language and unless he happens to be an absolute "dumbell" he will be a wiser man for having read it.

AXIAL FLOW FANS. By Curt Keller, Lionel S. Marks and John R. Weske. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York City. Size 6 by 9 in., 140 pp., cloth bound. Price $4.00.

Intended primarily for fan designers, this book is a real contribution to engineering literature, forming as it does almost the only definite link between an already fairly well established airfoil theory and the practical design of axial flow fans. Experimental investigations upon which the book is based verify the theoretical work and establish coefficients of performance to aid in design. The investigations were made by Curt Keller in the Escher-Wyss Laboratories in Switzerland and were first published in Europe. Professor Marks of Harvard, who has already published some investigations of his own on this subject, has, with the assistance of Prof. Weske of the Case School of Applied Science, translated Dr. Keller's work, abstracted it and arranged it so as to be of maximum value to the designer.

The book is divided into four parts, the first covering the theory of the axial flow fan; the second, fan losses and dimensions; the third, investigations of the action of blade profiles in retarded flow, while the fourth gives performance data of a series of axial flow fans ranging from 4 to 20 blades. In these fans both the guide vanes and runner blades were adjustable for angular setting so that it was possible to determine the best operating condition for each fan. This data is available in extensive tables and graphs.

CORNELL-DUBILIER CORP., So. Plainfield, N. J., is issuing its catalog 139 A, describing new pole-type capacitors for correction of power factor on electric distribution systems, to increase capacity of the systems for useful service.

BONNEY FORGE & TOOL WORKS, Allentown, Pa., has just issued a new Bulletin WT23, fully illustrating and describing WeldOlets and ThredOlets, the patented, drop-forged pipe fittings for making branch pipe connections by welding.

LIQUID LEVEL CONTROLLERS is the title of a new 16-page Bulletin, No. 2675 issued by Cochrane Corp., 3123 N. 17th St., Philadelphia, which illustrates and describes Cochrane liquid level controllers for services in power and process fields controlling levels and regulating flow of liquids to or from surge tanks, storage tanks, stills, receivers, absorber towers, heaters, condensers and evaporator units.

HEAT WITH BITUMINOUS COAL, the Modern, Economical Way, is the title of a booklet issued by the National Coal Association, Washington, D. C., and Stoker Manufacturers Association, Chicago, Ill., which Appalachian Coals, Inc., is distributing to its retail coal merchant customers. The booklet gives home owners, and prospective ones, recent scientific developments in the preparation, distribution and use of bituminous coal, listing 5 major points to consider and stresses the convenience. economy, dependability, cleanliness and health of coal heat.

DIESEL ENGINES AND THEIR LUBRICATION is the title of No. 4 in the series of booklets issued by Shell Petroleum Corp., 50 West 50th St., New York City. The series is written in simple form for executives, engineers and students, and the present number gives the principles, types, details of action, requirements for care in operation and growth in the use of the Diesel engine, interestingly told and attractively and instructively illustrated. Fuel and lubricating problems are discussed with suggestions as to how seller and user of fuel and lubricating oils may best coöperate to ensure economy and reduce labor and cost of upkeep. It is a treatise well worth careful reading and preserving for reference.

CONTINENTAL DIAMOND FIBRE CO., Newark, Del., has recently issued a bulletin entitled Celoron Silent Gears which describes the use of a laminated plastic in the making of all types of gear wheels. The bulletin contains considerable information on the strength and characteristics of this material as used in the manufacture of gears.

YARWAY EXPANSION joints are made the subject of bulletin EJ-1906 recently published by the Yarnall-Waring Co., Chestnut Hill, Philadelphia. These joints are made of wrought steel and designed with a cylinder guide, and considerable space in the bulletin is devoted to an explanation of the Yarway Gun-Pakt feature.

INLAND STEEL CO., 38 S. Dearborn St., Chicago, Ill., describes in an interesting booklet the Inland 4-Way Floor Plate designed for safety in power plants, factories and other locations where both wear and safety are of extreme importance.

PRINCIPLES OF OPERATION, design, layout and application of the steam jet cooler type of water vapor refrigeration for industrial and air conditioning purposes is covered in a new 24 page Bulletin No. 9143, just issued by Ingersoll-Rand Co., Phillipsburg, N. J.

WORKING DRAWINGS for a machine to test V-belts by methods given in the new SAE Standard for V-Belts and Pulleys are available as SAE Nos. 7-7-10 and 7-7-11. Orders should be addressed to Standards Department, Society of Automotive Engineers, 29 West 39th Street, New York. The price to members of the Society is 50 cents per set, to non-members $1.00 per set.

CAST-IRON pulleys for power transmission are treated in a new 8-page illustrated list price Book No. 1622 recently issued by Link-Belt Co., Chicago, Ill., giving pertinent data on solid and split, single and multiple arm machine-molded pulleys, with and without rubber lagging.

"THE FINEST Automatic Heat that money can buy," is the title of a sixteen-page book No. 1469-B just issued by Link-Belt Co., 2410 W. 18th St., Chicago, Ill., takes the reader pictorially through the features of automatic firing with coal. Primarily a picture book, it contains a series of illustrations from photographs taken in one of the thousands of homes heated by Link-Belt stokers. Other features displayed are; bin-fed model stokers, variable intermittent drive, airmeter automatic air control, automatic electric controls, load-signal automatic cutout and signal, automatic overload cutout, integral feed tube and air duct, and bridge-brace hopper construction.

THREE BULLETINS devoted to pumps have recently been issued by Fairbanks, Morse & Co., 900 So. Wabash Ave., Chicago. Bulletin 6205 describes reciprocating steam pumps suitable for a wide range of applications such as handling water, oil and similar liquids at pressures up to 420 lb. per sq. in. in quantities up to 464 g.p.m. Bulletin 6920 deals with oil lubricated, deep-well, turbine pumps used for most applications and Bulletin 6920R covers water lubricated, deep-well, turbine pumps which are used where the water must be kept pure and clean and oil lubrication is not permissible.

AN AIR SULPHUR content survey has just been completed by Dr. A. D. Singh, College of Engineering, University of Illinois, for the Chicago Department of Smoke Inspection and Abatement. It is expected this data will be put in published form soon.

THE MORSE CHAIN CO., Ithaca, N. Y., has issued its 1937 Silent Chain Engineering Data Book. In this 20-page booklet has been gathered detailed information on silent chains that plant engineers and production men most frequently require. A partial list of the new book's contents include horsepower tables, explanation of the different types of Morse silent chains and their applications, layouts of typical shoes and idlers, sprocket data, directions for cutting sprockets, how to calculate chain length, special sprockets and their uses, chain cases and methods of oiling. It is profusely illustrated with photographs, detailed drawings, and special graphs.

AMERICAN WELDING SOCIETY, 33 W. 39th St., New York, N. Y., has adopted a set of standard welding symbols covering fusion and resistance welding, which embodies a simple, graphical shorthand system to convey a large amount of information by a few simple lines and numbers. From the system can be selected the symbols needed for any work and, for unusual jobs, symbols can be added or supplementary data supplied. Complete information can be had from the Society.

APPLICATION of Diesel engines to more than 100 services including pumps, mines, hoists, sawmills, flour mills, generator sets, ice plants, oil wells, cotton gins, rock crushers, dredges and general construction work is described and illustrated in a new 32 page booklet, "Places for Power Supplied by Caterpillar Diesel Engines," just issued by the Caterpillar Tractor Co., Peoria, Ill.

APPLICATION of low pressure refrigerating units in 50 types and sizes ranging ¼ hp. up, to meet commercial needs is illustrated in Bulletin 97-C just issued by Frick Co., Waynesboro, Pa.

E. M. DART MFG. CO., Providence, R. I., gives complete data on Dart pipe unions and fittings in a new attractively illustrated catalog which is full of information on types, sizes and prices. In addition to tables giving dimensions, the catalog describes the precision operations, materials and methods of inspection used in the manufacture of these unions.

UNDER the title Forged Steel Flanges a new bulletin designated as No. 52,637 has just been issued by the Kropp Forge Co., 5301 W. Roosevelt Rd., Chicago, covering its line of forged steel stock flanges which includes boiler, tank, welding, marine, companion, offset, horseshoe, high hub, double hub, spud, blind and reducing flanges.

MINNEAPOLIS-HONEYWELL REGULATOR Co., has just issued a new bulletin covering the National Regulator line of air operated controls. The recent acquisition of National Regulator Co. of Chicago has enabled the company to offer what is known as three way Modutrol service—electric, pneumatic or combination of electric and pneumatic control.

MULTIPORT RELIEF VALVES are described by Cochrane Corp., 3123 N. 17th St., Philadelphia, in Bulletin No. 2710. These valves are recommended for service in the power and process fields as an effective safety valve where protection is desired against overpressure and consequent damages that may otherwise result by use of valves with single disks which are subject to sticking, jamming, overweighting or tying down.

KIRKALDY SYSTEM of electrolytic metal protection, as used to prevent scale in boilers, slime in condensers and corrosion is described and illustrated in Bulletin B-37-2 issued by Electrolytic Metal Protection, Inc., 247 Park Ave., New York, N. Y.

THE COMPLETE LINE of Micromax and other L & N pyrometer instruments are illustrated and briefly described in a new publication, Broadside N 33, issued by Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia.

STANDARD GAGES for Rain, Snow and Water Level is the title of a catalog recently issued by Julien P. Friez & Sons, Inc., Baltimore, Md. This new catalog covers an extensive line of instruments for all phases of research into the hydrologic cycle as well as for manifold industrial applications.

E. F. HOUGHTON & Co., Philadelphia, Pa., has just issued four pieces of literature dealing with products of its manufacture which are of more than passing interest. "Modern V Packings" is the title of one of the pamphlets dealing with results of research work on this type of packing. "Are Plant Surveys Profitable" takes up the question of lubrication as met in modern factories. "Off with the Old, On with the New" presents some observations on the modern group drive movement. "Bearing Metals and Lubrication" treats with so-called anti-friction bearing metal and improvements made during recent years in the life of these bearings.

A NEW CATALOG section describing the application, operation, construction and ratings of the Westinghouse Four Step Feeder-Voltage Booster-Regulator has recently been announced. Designed for use on rural lines or distribution circuits where the load changes over a wide range, these regulators are well illustrated in the publication with photographs, ratings, wiring diagram and outline dimensions.

INSULCRETE is the title of a bulletin recently issued by Quigley Co., Inc., 56 W. 45th Street, New York City, which describes this insulation and refractory material used extensively in the construction of furnaces where light weight, resistance to high temperature and monolithic qualities are essential.

BUILDING BETTER pipe lines faster at less cost by shielded-arc welding is the title of bulletin 418 recently issued by The Lincoln Electric Co., Cleveland, Ohio. The bulletin contains considerable technical data on welding as well as many photographs and tables of value to the welding engineer.

ENGINEERING PROPERTIES of "K" Monel is the title of Bulletin T-9 recently issued by The International Nickel Co., Inc., 67 Wall St., New York, N. Y. The bulletin is full of characteristic curves and tables of value to the engineer in selecting metals for construction of industrial equipment. Catalog Note

BULLETIN No. 222 recently issued by Whiting Corp., Harvey, Ill., describes the benefits derived from the use of Whiting H.C. Stokers, and Bulletin No. 224 presents a variety of designs of jib and pillar cranes.

1936 OIL ENGINE Power Cost Report on fuels, lubrication, attendance, supplies and miscellaneous, engine and plant repair costs is now available from the American Society of Mechanical Engineers, 29 W. 39th St., New York City, at $1 a copy. Tables cover power production costs, comparative cost data 1929 to 1936, and engine details.

TURBINE PUMPS are described and illustrated in Bulletin 260-B11C just issued by Roots-Connersville Blower Corp., of Connersville, Ind. Special emphasis is placed on their wide application throughout the industrial field.

BULLETIN 1832 of Allis-Chalmers Mfg. Co., Milwaukee, Wis., is a new 24-page treatise on Perforated Metals for all applications requiring rolled or flat plates, in all common commercial grade of steel plates or sheets.

BULLETIN 1541 on Steel Shell Surface Type Steam Condensers has been released by Allis-Chalmers Mfg. Co., of Milwaukee, Wis. In addition to a well illustrated section on condensers it includes related auxiliary equipment such as motor and turbine driven condensate pumps.

USES OF Hearth-Crete for refractory linings are shown in a new bulletin from Quigley Co., Inc., 54 W. 45th St., New York City. Its advantages in speed, economy and resistance to slag penetration are explained.

WHEELCO INSTRUMENT CO., 1929 South Halsted St., Chicago, has just issued an eight-page bulletin on their new Model 1101 Flame-otrol, a gas burner safety device designed to shut off the gas flow in case of flame failure.

LATEST INFORMATION on the complete line of TAG Indicating, Recording and Control Instruments for Temperature and Pressure is included in the 56-page catalog, 1060C, just issued by the C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn.

EMBRACING 120 pages of practicable data about Youngstown special wrapped and lined steel water mains, also technical information for engineers and officials of water works, public and private utilities, governmental units, and large industrial users of water mains, a Water Works Manual has just been published by The Youngstown Sheet & Tube Co. It is in loose-leaf form, with permanent binder, to facilitate the addition of facts and data which will be sent out from time to time. Useful tables and charts cover basic hydraulic information and engineering data used in water main flow capacity and pipe line computations. Engineers and officials interested may obtain copies by writing to the Water Works Division of The Youngstown Sheet and Tube Co., Youngstown, Ohio.

C. O. BARTLETT & SNOW CO., Cleveland, Ohio, announces the completion of a new catalog No. 77, giving complete details of its single roll, two-roll and four-roll coal crushers, coke crushers, crushing rolls, swing hammer pulverizers, rotary crushers, disintegrators, ball mills, plunger, plate, screw, apron, pocket, cutting and table feeders. The booklet contains 44 pages of engineering diagrams, capacity tables, suggestions for use, and is completely illustrated. Copies may be secured from the Company on request.

B. F. GOODRICH CO., Akron, O., has just issued a new 20-p. manual on care and maintenance of conveyor and elevator belting, illustrated with drawings and job photographs and written in practical language for operating men. It takes up such matters as: saving wear, at loading point, by proper idler spacing and by reduced speeds; protection from lumps; causes and remedies of excessive tension, and tension formula; proper installation and making belts run straight; splicing, repairing and fasteners; specifications for new belts. Copies may be obtained by addressing the Mechanical Rubber Goods Division, B. F. Goodrich Co., Akron, Ohio.

Power Plant Construction News

Ala., Mobile—National Gypsum Co., 190 Delaware Avenue, Buffalo, N. Y., plans installation of electric power equipment in new gypsum products plant at Mobile, where tract of land is being acquired. A power house will be built for mill service. Entire project will cost close to $2,000,000. Melvin H. Baker is president.

Calif., Long Beach—Proctor & Gamble Co., Long Beach, plans installation of electric power equipment in new additions to local plant, designed to double present capacity. Entire project will cost about $1,000,000. Work is scheduled to begin soon. Executive offices of company are in the Gwynne Building, Cincinnati, Ohio.

Calif., Montalvo—Saticoy Lemon Association, Montalvo, plans installation of electric power equipment in two new additions to citrus fruit packing plant, one-story, 125x170 ft., and two-story, 155x 210 ft., respectively. Also will install mechanical-handling apparatus. Entire project will cost close to $100,000. Roy C. Wilson, Santa Paula, Calif., is architect.

Colo., Denver—Bureau of Reclamation, Custom House, Denver, will receive bids until September 7 for two 230-kv., three-pole disconnecting switches, and for two 230-kv., three-phase, outdoor type lightning arresters for installation in Boulder Power Plant, Boulder Canyon Project, Arizona-California-Nevada. All equipment will be installed by Government (Specification 960-D).

Conn., New Britain—Landers, Frary & Clark, Inc., manufacturer of electric heating and cooking appliances, etc., has approved plans for new boiler house at plant, 20x63 ft., with installation to include boiler unit and accessory equipment. Company will install electric power equipment in new one and five-story factory addition. Entire project will cost close to $200,000. W. F. Brooks, Lewis and Gold Streets, Hartford, Conn., is architect.

Conn., New Haven—Pond Lily Co., Whalley Avenue, plans installation of power equipment in new addition to textile dyeing and finishing plant, one-story, 105x185 ft. Cost over $80,000 with machinery. Marvin R. Hamer, New Haven, is architect.

Idaho, Kendrick — Clearwater Valley Light & Power Association, 1206 Main Street, Lewiston, Idaho, plans early construction of electric power plant at Kendrick for power supply for rural power system. Installation will include diesel engine-generator units and accessory equipment. Initial fund of $75,000 has been arranged through Federal aid for plant, and additional appropriation is planned. T. C. Smith is chief engineer.

Ill., Chicago—Lady Esther Co., 2012 Ridge Avenue, Evanston, Ill., plans installation of electric power equipment in new one-story cosmetic manufacturing plant, 200x500 ft., at Harlem Avenue and Sixty-fifth Street, Chicago, where site has been acquired. Entire project will cost close to $450,000. Albert Kahn, Inc., New Center Building, Detroit, Mich., is architect and engineer.

Ind., Evansville — Sunbeam Electric Mfg. Co., West Morgan Street, manufacturer of automobile headlights, etc., plans installation of electric power equipment in new one and three-story additions to plant. Cost about $250,000. Edwin C. Berendes, 121 N.W. Fourth Street, Evansville, Ind., is architect.

Iowa, Corning—Board of Trustees for municipal electric power plant will receive bids until Sept. 7 for one Diesel engine-generator unit, 575 to 725-hp., capacity, and auxiliary equipment, for installation in station. Fund of $50,000 has been authorized for unit and installation.

La., Abbeville—Common Council has authorized improvements in municipal electric power plant, including installation of new 1000-hp. engine-generator unit and auxiliary equipment. Work will begin soon. Cost estimated about $50,000. A. J. Frank, superintendent of Water and Light Plant, is in charge.

La., Thibodaux—Waverly, Inc., Canal Bank Building, New Orleans, La., A. F. Delbert, head, plans installation of boilers and other power equipment in Waverly cane sugar mill at Thibodaux. Entire project will cost about $75,000.

Mich., Lansing — City Council has plans nearing completion for large multi-story addition to municipal electric power plant, to include installation of turbo-generator unit, boiler and auxiliary equipment for increased capacity. Cost about $2,750,000. Bowd & Munson, Lansing, are architects; Claude Erickson, Lansing, is engineer.

Mich., Lansing—Motor Wheel Corporation, East Saginaw Street, plans installation of electric power equipment in two new one-story plant additions for production of automobile brake drums, totalling about 90,000 sq. ft. of floor space. Entire project will cost over $200,000.

Neb., Gering—United Artichoke Co., Scottsbluff, Neb., Ernest W. Johnson, general manager, plans installation of electric power equipment in group of five dehydrating and processing plants at Gering, Indianaola, Ord and other points in Nebraska. Proposed to begin work soon. Entire project will cost over $350,-000.

Neb., Omaha — Roberts Dairy, 2901 Cumming Street, has approved plans for one-story addition to boiler house at milk products plant, 20x45 ft., to include installation of new boiler unit and auxiliary equipment. James T. Allan, Brandeis Theater Building, is architect.

N. J., Grasselli — General Aniline Works, Inc., 435 Hudson Street, New York, N. Y., plans installation of electric power equipment in new addition to dye and color manufacturing plant at Grasselli, near Linden. Work will be placed under way soon. Entire project will cost about $450,000.

N. J., Linden—Mather Spring Co., 755 Castle Boulevard, Toledo, Ohio, plans installation of electric power equipment in new branch plant at Linden, where large tract of land has been purchased, for manufacture of steel springs for automobiles. Initial unit will be one-story, 220x420 ft. Entire project will cost over $250,000.

Ohio, Cleveland—Wellman Bronze & Aluminum Co., 6017 Superior Avenue, plans installation of electric power equipment in new addition to bronze bearing and bushing manufacturing plant, to double present floor space. Entire project will cost over $100,000. Work will begin early in fall. F. S. Wellman is president.

Okla., Blackwell — City Council has plans maturing for extensions and improvements in municipal electric power plant, including installation of additional equipment. Cost about $300,000. A bond issue is being arranged in amount noted. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Okla., Ponca City—Continental Oil Co., Ponca City, plans installation of a compressor plant, boiler house and pumping station in connection with new natural gasoline plant, to be equipped to process about 20,000,000 cu. ft. of natural gas per day. A steel tank storage and distributing terminal will be built. Entire project will cost close to $200,000.

Pa., New Castle — Pennsylvania Power Co., Youngstown, Ohio, has awarded erection contract for new power plant building at West Pittsburgh, near New Castle, where large tract of land was acquired recently, to J. A. Utley, 6031 Masur Street, Detroit, Mich., and work on project will begin soon. Turbo-generator units, high-pressure boilers and auxiliary equipment will be installed for large capacity. Entire project will cost about $3,000,000 and is scheduled for completion late in 1938.

Texas, Corpus Christi—Southern Alkali Corporation, Corpus Christi, plans installation of power equipment, pumping machinery and other mechanical equipment in new additions to plant for an electrolytic chlorine division and by-product salt division, respectively, each to comprise three large building units. Erection contract will be carried out by H. K. Ferguson Co., Hanna Building, Cleveland, Ohio. Cost over $750,000. O. N. Stevens is vice-president in charge of operations.

Texas, San Antonio—E. L. Buckley, Alamo National Bank Building, San Antonio, is at head of project to construct and operate an oil refining plant, using crude oil from Premont and North Sweden oil fields, to include power house, pumping station and steel tank storage facilities, with welded steel pipe line to point near Corpus Christi, Texas, where large terminal storage and distributing plant will be built. A pumping station for pipe line booster service will be constructed near Alice, Texas. Entire project will cost close to $1,000,000.

Va., Harrisonburg — Shenandoah Valley Electric Co., Harrisonburg, has plans maturing for new steam-electric power plant on local site, for power service for rural electric system, now in course of construction in parts of Page, Shenandoah and neighboring counties. Fund of $55,000 has been secured through Federal aid for power station.

W. Va., Lumberport — Harrison County Rural Electrification Association, Lumberport, has plans maturing for new steam-operated electric generating plant for power supply for rural electric system in Harrison and neighboring counties. Fund of $100,000 has been arranged through Federal aid for plant. E. V. Richardson is chairman.

Wis., Green Bay—Green Bay Soap Co., 1484 Crooks Street, plans installation of power equipment in new two and three-story plant addition. Company will also build a new 100-ft. stack at power house and install a 50,000-gal. water tank. Entire project will cost about $80.000. C. H. Williams, 212 Pine Street, Green Bay, is architect.